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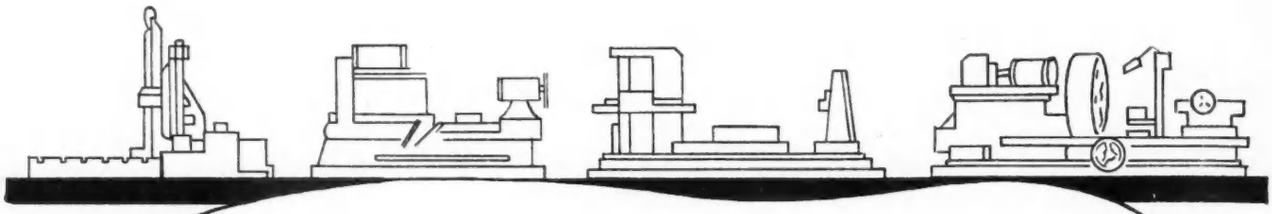

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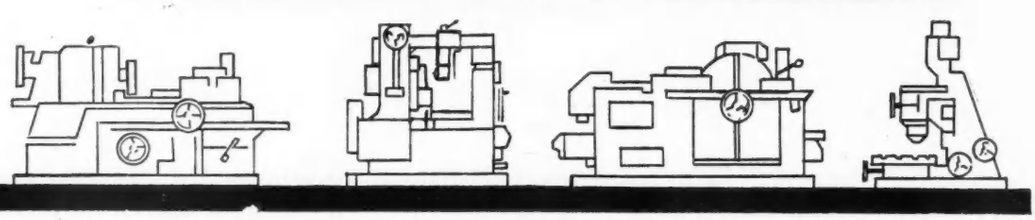

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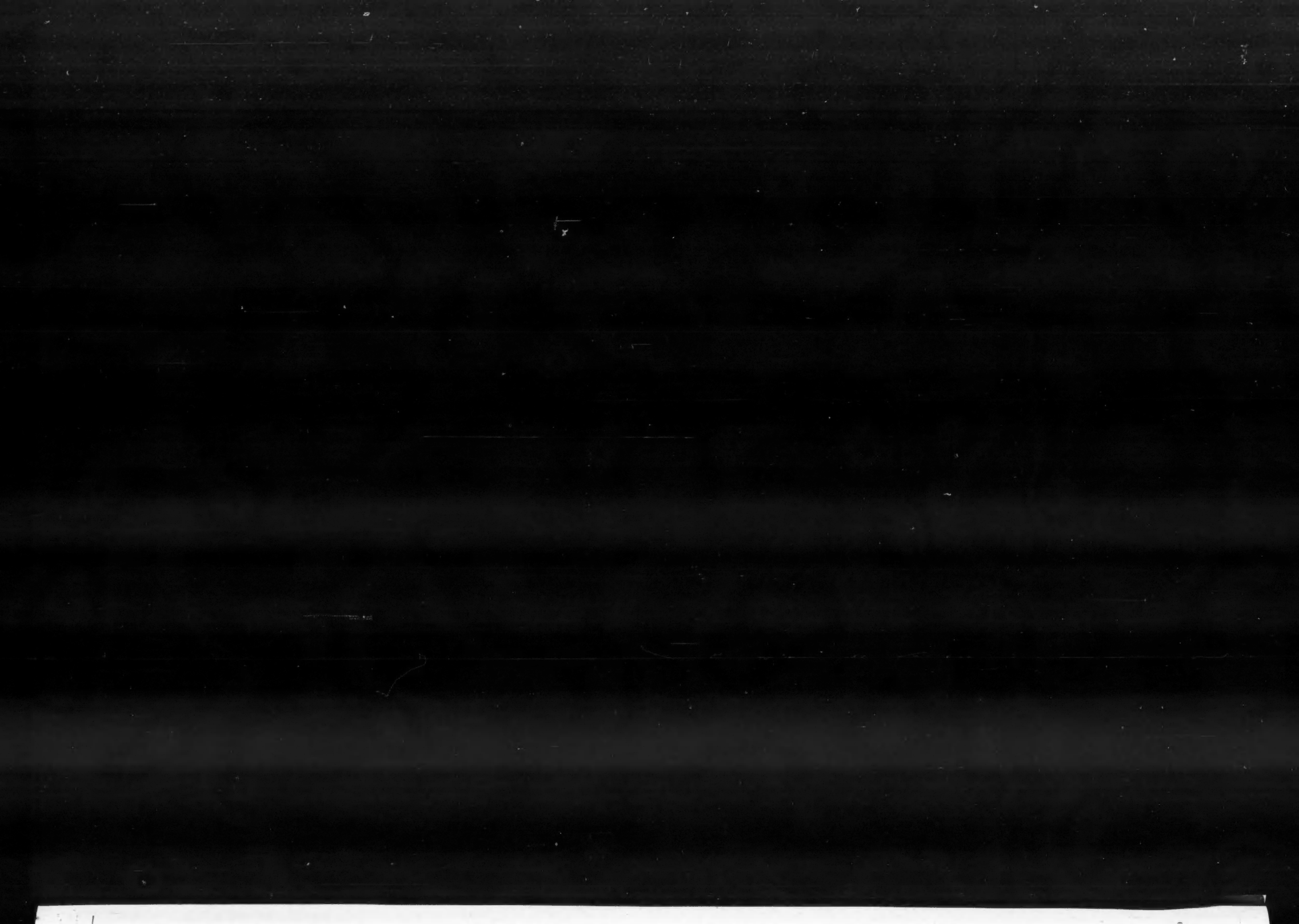


MODEL STRUCTURES FOR ENGINEERING TRAINING.

By R. J. WILKINS, M.Sc.(Eng.), A.M.I.C.E.

THE theory and design of structures forms an important part of a civil-engineering course in universities and technical colleges, instruction usually taking the form of lectures, drawing-office design practice and experimental work. The lectures deal with the theoretical aspects of the subject and are related to the drawing-office practice, where the designs carried out are chosen to illustrate the fundamental principles involved and also, as far as possible, to introduce some degree of familiarity with the practical difficulties of design. The item "experimental work" contributes much to a clear appreciation of a problem, but the extent to which this may be developed is often limited by the lack of suitable apparatus. Suggestions which would considerably improve the position were made by Professor A. J. S. Pippard during the Summer School for Teachers in Technical Colleges held in July, 1946, at New College, Oxford, and published in a recent book which should lead to a more enlightened approach to the study of structures.*

Most technical institutions are able to manufacture a reasonable amount of equipment in their own workshops through the collaboration of the lecturers concerned and the workshop staff. In such cases it is usually found to be unwise to prepare fully detailed working drawings of the apparatus required owing to the present shortages of material and the practical certainty that, owing to this, some design modifications will be required. A better plan is to prepare an outline design of the equipment and to adapt this design to the available materials and tools as the manufacture of the apparatus proceeds. The demand for laboratory apparatus covering a wide range is particularly heavy at present owing to the number of students, both full-time and part-time, in training, and it is sometimes difficult to provide adequate experimental facilities. It is expected therefore that the three sets of equipment described below will be of interest as representing designs which have proved successful and are generally within the manufacturing capacity of a college workshop. The accompanying illustrations are not fully dimensioned, but, using the particulars given as a basis, the design may be modified as required. No claim for originality of design can be made for equipment of this type, but considerable thought has been given to the various design details to produce apparatus that would work efficiently, give reasonable results, and withstand frequent and heavy use by students. A small "structures" laboratory can be built up gradually with apparatus of this type, and the interest of the subject considerably increased by its use. In the present case, each set of apparatus is mounted on a table, all being uniform in height; the Bakelite surface has the leading particulars of the structure engraved upon it.

* *The Experimental Study of Structures.* By Professor A. J. S. Pippard. Edward Arnold and Company, London. [Price 9s. net.]

Fig. 1.

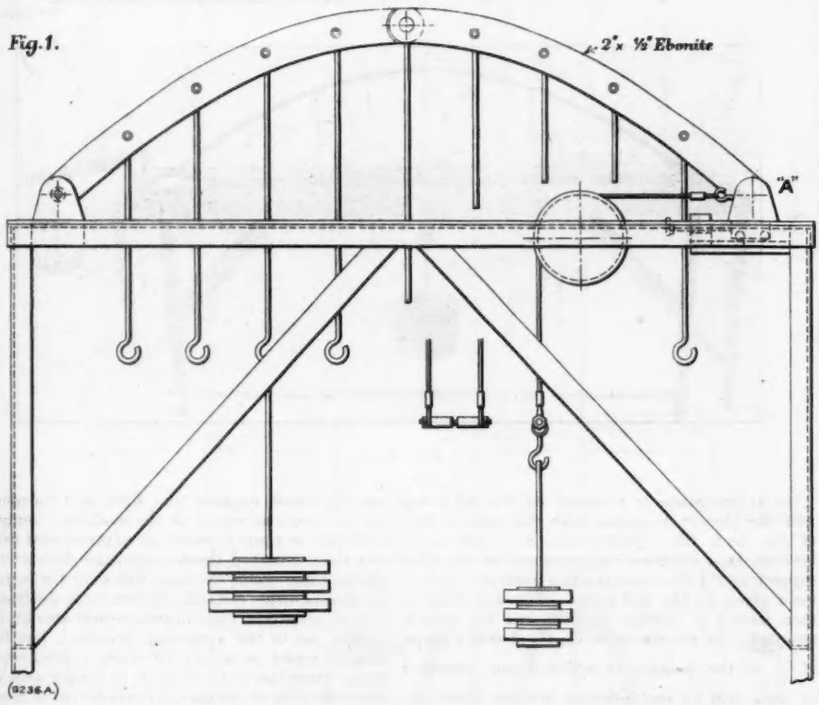


Fig. 2.

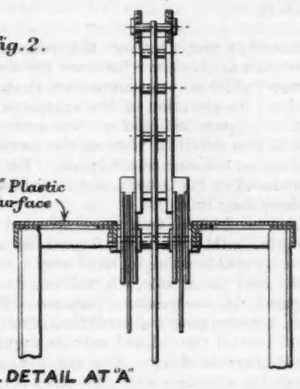
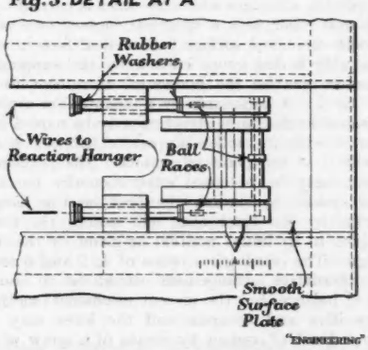


Fig. 3. DETAIL AT "A"



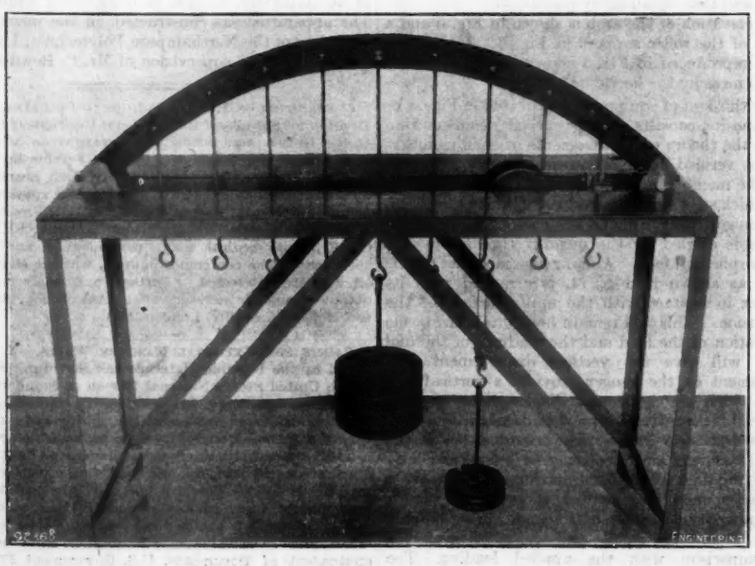


FIG. 4.

The apparatus described and illustrated consists of a three-hinged arch, a two-hinged arch, and a quadrant, ring, davit, etc., each complete in itself, the only additional equipment being weights, hangers and a dial gauge with adjustable stand. The use of the apparatus is described without giving any of the theory involved, which is mostly standard work and dealt with in the lectures taken throughout the same course of study as that in which the experimental apparatus is used.

The three-hinged arch is constructed of 2-in. by ½-in. ebonite curved to parabolic form, with a horizontal distance between the pins of 40 in. and a central rise at the crown pin of 9·6 in. The ebonite members are held by distance bolts which are also used to carry the load hangers. At one end the rib is carried by a pin and at the other by a movable support running on three ball-races to give "three-point contact." Two horizontal wires passing over pulleys carried by the supporting frame enable the horizontal reactive force to be applied. The weight of the arch rib itself is first balanced and the horizontal thrust for any load system may then be found experimentally by finding the load which when applied to the hanger will maintain the loaded arch in equilibrium at the 40-in. span position. This experimental value may be compared with that obtained by the statics of the arch. By moving a constant load along the arch to each position in turn and finding the horizontal thrust experimentally in

MODEL STRUCTURES FOR ENGINEERING TRAINING.

Fig. 5.

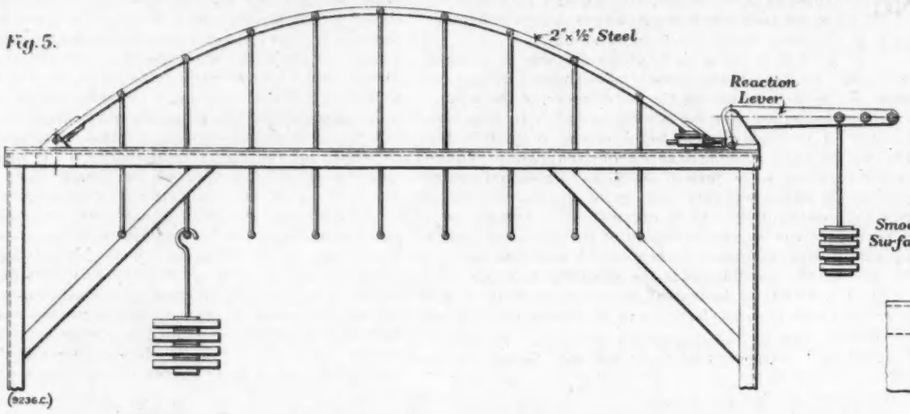
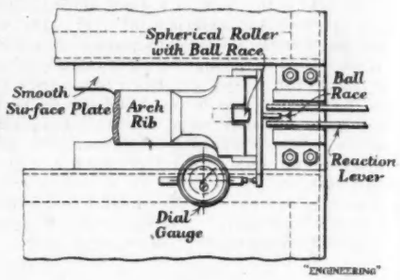


Fig. 6.



each case, a graph between this value and the load position will give the "influence line for horizontal thrust" which may be compared with the theoretical value. An elevation of the apparatus is given in Fig. 1, on page 385, and a cross-section in Fig. 2; Fig. 3 is a detail in plan of the movable support running on a machined-steel plate. The photograph reproduced in Fig. 4 will assist in the interpretation of these diagrams.

The two-hinged arch is constructed from 2-in. by ½-in. mild-steel strip formed to a parabolic curve by cold bending by hand over a wooden block while held in a vice. A full-size template was prepared for comparison purposes. The arch is 50 in. between pins, measured horizontally, and has a 10 in. central rise. Load may be applied at horizontal intervals of 5 in. One pin is attached to the supporting structure while the other is carried by a ball-race roller with a spherical contact face on a smooth machined surface. A vertical face in contact with a dial gauge carried by the supporting structure enables the horizontal movement to be measured. A bell-crank lever mounted on a pivot attached to the frame structure may be moved into contact with the roller support, a ball-race being provided at the point of contact. The horizontal thrust may be obtained experimentally for any load system by finding the load on the hanger carried by the lever that will restore the roller support to its initial position as given by the dial gauge. The crank gives ratios of 4, 5 and 6 to 1. An alternative arrangement would be to use a spring balance, but the present mechanical method is positive and accurate and the lever may be fastened out of contact by means of a screw when not required. To prevent damage to the dial gauge, should excessive load be applied to the crank, an adjustable stop is provided on the lever which makes contact with the supporting bracket.

This apparatus is used for the following experimental work. (*a*) The lever is moved out of contact and secured by the screw. The dial gauge is then set to zero and observations made and tabulated between an applied central load and the horizontal movement at the roller. A graph between central oad and horizontal displacement may then be compared with the theoretical values obtained by analytical methods.

(*b*) The lever is moved into contact and the dial gauge set to its zero reading with the hanger in place. A load of 20 lb. is then moved to each position in turn, and in each case the horizontal reactive force required to maintain zero reading on the dial gauge is found experimentally. These values when plotted against the load position give the influence line for horizontal thrust which may then be compared with the value obtained by considering the strain energy due to bending and given by

$$H = \frac{5 W a b}{8 L^3 r}(a^2 + 3ab + b^2).$$

where H = horizontal thrust, W = applied load, L = horizontal span, r = central rise, a = distance of load from one pin, and b = distance of load from other pin.

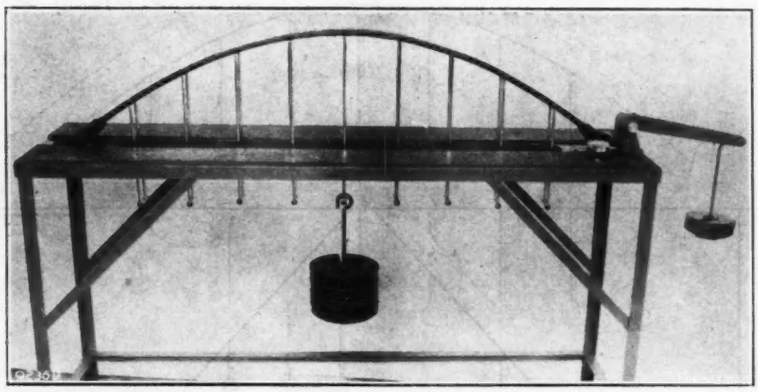


Fig. 7.

(*c*) A dial gauge is mounted on the table top with the plunger in contact with the upper surface of the arch rib. Observations are then made between D, a horizontal displacement at the roller support and d the corresponding vertical displacement given by the dial gauge. The dial gauge is then moved to another position and the process repeated. By the theory of elastic models a graph of $\frac{d}{D}$ to the position at which d was measured as base, will be the influence line for horizontal thrust which may be compared with the theoretical value and that obtained by method (*b*).

An elevation of the arch is shown in Fig. 5 and a detail of the roller support in Fig. 6. The photograph reproduced in Fig. 7 shows the lever in contact to measure the horizontal thrust.

The third set of equipment, illustrated in Figs. 8 to 13, opposite, consists of four curved members from which the theory of displacements of such members may be verified by experimental evidence. In each case the member is constructed from 1¼ in. wide by ⅛ in. thick steel strip, the load being applied by a vertical hanger. Fig. 9 shows the manner in which the hanger is carried by the member through contact with a spherical face. A dial gauge mounted on the table, as shown in Fig. 14, is arranged with its plunger in contact with the upper surface of the suspension. This will remain horizontal during the application of the load and the readings of the dial gauge will give the vertical displacement. An attachment on the hanger provides a vertical face from which the horizontal displacement may be obtained if desired. To prevent damage adjustable collars and stop angles are provided below the table as shown, and these may be set permanently at the required limit to the movement. Adequate clearances must be provided, of course, to permit free movement. The dial gauge spring-plunger forces are very small and may be neglected in comparison with the applied loading. The attachment of the vertical portion of the quadrant and the davit requires care since any movement will have serious results on the readings. Comparisons may be made between the experimental values and those obtained theoretically, the derivation of which forms useful exercises following the lectures on strain-energy methods of structural analysis.

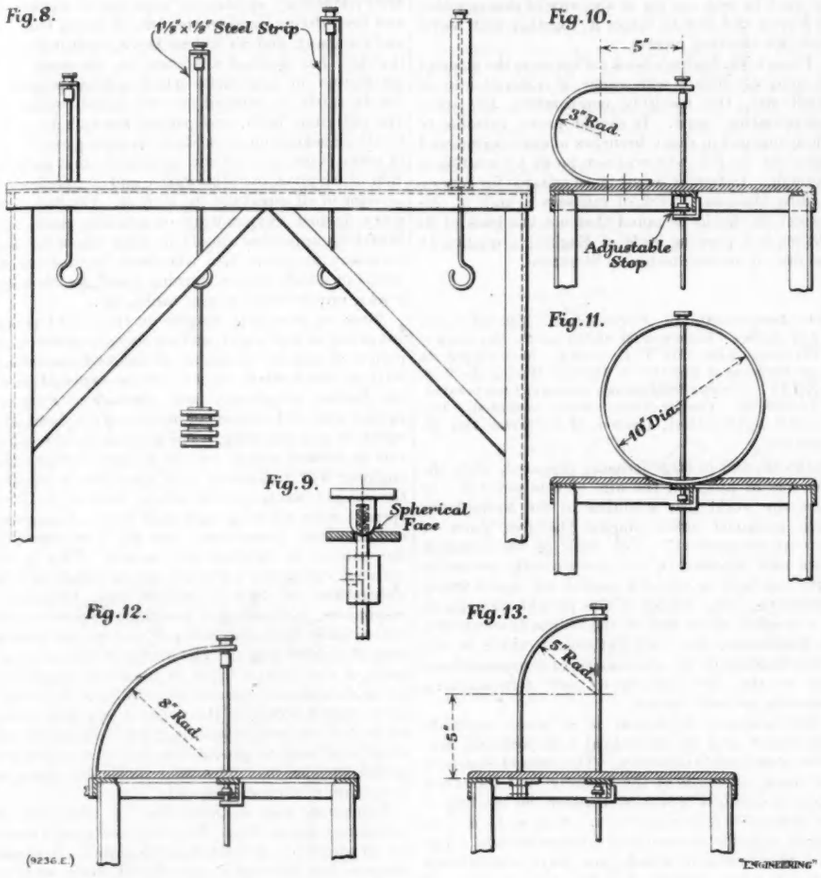
In all cases good experimental results are obtained by the use of the apparatus described, but little purpose would be served by giving typical sets of results since the main object is to supply sufficient information to encourage the development of similar apparatus with consequent benefit to the teaching of an important subject in engineering education. The apparatus was constructed in the instrument workshop of the Northampton Polytechnic, London, E.C.1, under the supervision of Mr. C. Bowden.

Conference on Human Factors in Industry.—The Division for Social and International Relations of Science of the British Association have arranged an afternoon and evening conference on "Human Factors in Industry," to be opened in the Assembly Hall, Leamington Spa, at 2 p.m., on Saturday, May 8. The speakers will include Sir Henry Tizard, K.C.B., F.R.S., President of the British Association, Sir George Schuster, K.C.M.G., C.B.E., and medical men, psychologists and other specialists. The conference is open, without charge, to all who are interested. Further particulars may be obtained from the secretary of the Association, Burlington House, Piccadilly, London, W.1.

Paints for External Masonry Walls.—A report issued by the Building Materials and Structures Section of the United States National Bureau of Standards has recently come to hand. It describes the results obtained using cement-water, resin-emulsion, oil-base and synthetic rubber paints, and one whitewash, on walls of new and used brick; cast-concrete; stone, cinder, and lightweight aggregate concrete blocks, and wood frame with cement-asbestos shingles. The durability of the paints has been judged from tests and observations conducted over a period of about three years. Copies of the report, price 15 cents net, may be obtained from the Superintendent of Documents, U.S. Government Printing Office, Washington 25, D.C., U.S.A.

MODEL STRUCTURES FOR TRAINING.

(For Description, see Opposite Page.)



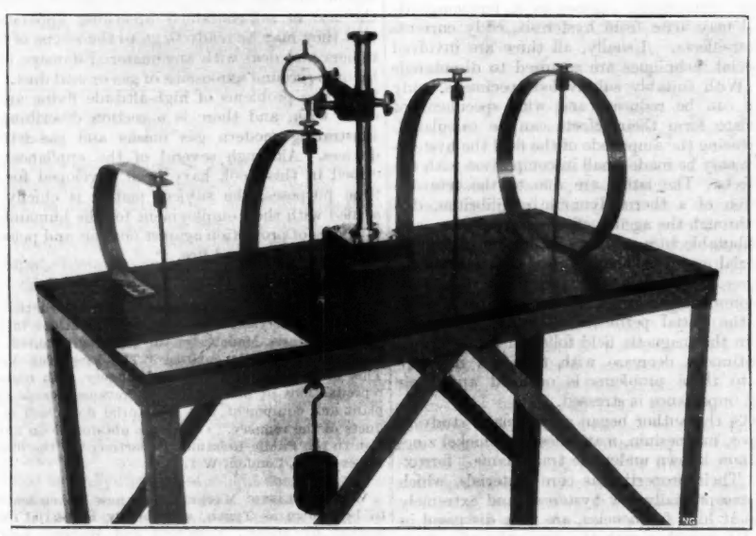


FIG. 14.

SOCIETY OF MODEL AND EXPERIMENTAL ENGINEERS.—Founded in 1898, the Society of Model and Experimental Engineers are to celebrate their golden jubilee by holding an exhibition in the Exhibition Pavilion, Imperial Institute, South Kensington, London, S.W.7, from May 13 to 22. It will be open from 11 a.m. until 9 p.m., on each day, and admission will be 2*s.* 6*d.* for adults and 1*s.* 3*d.* for children. Among the exhibits will be models of steam, petrol and other engines of all periods, working model locomotives and railway layouts, sailing ships, power boats and aeroplanes. In a special workshop, lathes and other machine tools and testing equipment will be shown in operation. The President of the Society is Lord Forres, and the list of past-presidents includes such names as Dr. Hele Shaw, F.R.S., Admiral Sir Reginald Bacon, K.C.B., Sir Felix Pole and the Earl of Northesk. The Society's workshop and library are at 20, Nassau-street, W.1. Further information regarding the Exhibition may be obtained from the Exhibition Manager, 28, Bolton-street, W.1. (Telephone: GROsvenor 2911.)

LITERATURE.

Elements of Applied Energy. By PROFESSOR F. T. MORSE. D. Van Nostrand Company, Incorporated, 250, Fourth-avenue, New York, 3, U.S.A. [Price 6 dols.]; and Macmillan and Company, Limited, St. Martin's-street, London, W.C.2. [Price 30*s.* net.]

THE author of this book considers that those students of applied thermodynamics whose course of study is relatively short will derive the greatest benefit from a more descriptive than scientific treatment of the subject, and that this will provide potential specialists with the foundation required for work of a more advanced character. In his interesting and comprehensive survey of heat energy and its applications, more emphasis is therefore placed upon the practical form and operation of the various machines and equipment than upon the theoretical principles involved. The way in which the subject matter has been presented and arranged could hardly be improved. The first five chapters provide the necessary introduction and deal with the general physical and thermodynamical properties of gases and steam, fuels and products of combustion, fundamental principles relating to heat transfer and heat-work transformation, and mechanical details of heat engines. The application of heat energy for purposes other than the production of work, such as air compression, refrigeration and air-conditioning, is explained in Chapters 6 and 7. The next three chapters deal with work derived from direct combustion and explain the operation of the internal-combustion engine, the gas turbine, and the fundamental principles of jet propulsion. Work derived from indirect combustion forms the subject matter for Chapters 12, 13 and 14, which deal with boiler practice and the operation of various types of steam power plant. The final chapter describes various equipment of an auxiliary nature.

Although, as stated, the treatment is largely descriptive, the theoretical side of the subject is satisfactorily explained without going into too much detail, and the practical application of theoretical principles is well illustrated by numerical examples. Additional problems are set at the end of each chapter. The use of the calculus has been avoided and only a good knowledge of algebra and trigonometry is necessary. The illustrations are particularly good, but the occasional use of formulæ without adequate proof may be criticised. The course of work suggested by this book is worth studying by those who are directly concerned with or merely interested in the teaching of applied thermodynamics not only to university students but also to part-time students working for the Higher National Certificate.

Technical Aerodynamics. By PROFESSOR KARL D. WOOD. McGraw-Hill Book Company, Incorporated, 330, West 42nd-street, New York 18, U.S.A. [Price 5.50 dols.] McGraw-Hill Publishing Company, Limited, Aldwych House, Aldwych, London, W.C.2. [Price 33*s.*]

THIS book is nominally a second edition, the first having been published in 1935, but it may be regarded as new, since little has been retained of the first edition apart from the chapter headings. The main body of the book, covering 375 pages, consists of an introduction and eleven chapters, the remaining 90 pages or so being devoted to six appendices and the index. The appendices are, in fact, data sheets in which are collected tables and charts supplementing those of the text. The introduction briefly reviews the layout, construction and instruments of some representative aircraft. Then follows an omnibus chapter, headed "Mechanics and Thermodynamics of Air," dealing rather sketchily with hydrostatics, elementary thermodynamics, the atmosphere, fluid dynamics, heat transfer and dimensional analysis. The next chapter deals with aerofoil characteristics, wind tunnels and high-lift devices. The estimation of parasitic drag (defined as total drag less induced drag) is the main subject of the next chapter, which concludes with a discussion of the power required for level flight. This is followed by a chapter on the characteristics of engines (including jet and turbo-jet engines) and propellers. The next four chapters are devoted to performance problems, such as the estimation of

the rate of climb, landing and take-off distances of ordinary aircraft, seaplanes and flying boats; and a brief discussion of performance flight-testing follows. Emphasis is laid on the use of a general non-dimensional plot, on logarithmic scales, of power required against forward speed. The three remaining chapters deal with the characteristics of control surfaces, and longitudinal and lateral stability. The data in the appendices cover units and conversion factors; properties of some liquids and gases; the standard atmosphere; the characteristics and ordinates of some 200 aerofoil sections; the effects of scale, aspect ratio and taper (compiled from variable-density tunnel test results); span and chord-wise load distributions; representative parasitic drag values; level speed, climb and ceiling charts and a considerable number of performance charts of some typical propellers.

As a collection of empirical data and current American methods, the book is undoubtedly of first-rate value to designers and their staffs. There are a few misprints, but none is seriously misleading; and a valuable feature is the liberal provision of excellent examples. The treatment of fundamentals, however, is barely adequate; it is overcondensed and at points misleadingly simple, and mathematics, except of the most elementary kind, has been too rigorously avoided. The serious student will need to supplement the book by others dealing more comprehensively with the science, as distinct from the technique, of aerodynamics. A point that calls for comment is the almost complete absence of references to British work. Even such fundamental work as the calculation of the profile drag of aerofoils (R. and M. 1838) and Gates manœuvrability criteria are not mentioned. It is hoped that before a third edition is prepared the author will realise that his readers have much to gain from being made aware of aerodynamic literature outside the United States.

Pressure Vessels for Industry. By HARRY M. SPRING, JUNR. McGraw-Hill Book Company, Incorporated, 330, West 42nd-street, New York 18, U.S.A. [Price 3.50 dols.], and McGraw-Hill Publishing Company, Limited, Aldwych House, Aldwych, London, W.C.2. [Price 17*s.* 6*d.*]

THE term "pressure vessel" is given a very comprehensive interpretation in this book, which is concerned with a wide range of industrial processes. The first seven chapters are devoted to brief descriptions of characteristic vessels to be found in the paper, rubber, textile and chemical industries, as well as in auxiliary systems such as steam, hot-water and compressed-air services. Only incidental reference is made to boiler plant, as the author has covered that subject in his *Boiler Operator's Guide*, published in 1940. The rest of the book deals with design, methods of fabrication, accessories, and, finally, under the heading "Defects," with such factors as cracks, corrosion and other kinds of deterioration, the dangers they involve, and the appropriate preventive measures.

The first part contains thumb-nail sketches of many of these processes, in some cases assisted by diagrammatic flow-sheets; it is thus a useful primer for students of chemical engineering, although the cursory way in which each item has to be treated may give the uninitiated a dangerously oversimplified conception of the problems involved. The same applies to the chapter on design, which quotes a number of simple formulæ and then refers to the appropriate A.S.M.E. Codes. An appendix gives further information of this kind, although it refers specifically to American practice. The designs mentioned include a considerable variety of cylinders, spheres and dished ends of both welded and riveted construction, but, in view of the lack of explanatory detail, a list of selected references would be a useful addition. Discussion of the problem of thick-walled cylinders is entirely omitted. There is little mention of ultra-high pressure plant, but several of the items illustrated must have involved in their design factors not dealt with in the text. In dealing with fabrication technique, there is much useful information on protective linings, and "clad" steels and what can be done with them, but again there is a tantalising shortage of detail. The A. O. Smith "multi-layer" system is described with several excellent photographs. A good selection of typical valves is given in the chapter headed "Appliances," which also deals briefly with pressure and temperature measurement. The final chapter is one of the best, containing much sound advice on what to look out for in the way of deterioration in service and how to detect it, together with useful hints for effecting repairs.

Though Mr. Spring's book suffers from the attempt to compress such a wide range of material into its small size, the resulting compactness has some compensating merit. It should prove valuable to those engaged in many branches of engineering, and there can be few who will not profit by reading it through. In fact, it seems more suitable for general reading than as a work of reference; and, in this respect, it should be noted that not the least of its virtues is a pleasing style of English, a quality all too rare in modern technical literature.

New Developments in Ferromagnetic Materials, with Introductory Chapters on the Statics and the Dynamics of Ferromagnetism. By J. L. SNOEK. Monographs on the Progress of Research in Holland During the War, No. 19. Elsevier Publishing Company, Incorporated, Amsterdam. Cleaver-Hume Press, Limited, 42*a*, South Audley-street, London, W.1. [Price 13*s.* 6*d.* net.]

PLANNED, and in large measure prepared, while the war was in progress, the aim of this series is "to show the world that scientists in the Netherlands have remained active during the five years of German occupation." The bulk of the research work now reported in this conveniently accessible form was kept secret and carried out under trying conditions. The author of the present monograph is a member of the staff of the Philips Laboratories, at Eindhoven, the contributions of which to the understanding of the phenomena of ferromagnetism and to the development of new ferromagnetic materials are well known.

Ferromagnetic hysteresis is of great technical importance and its theoretical interpretation presents considerable difficulty. The present status of the theory in terms of the inclusion and the stress model is outlined in section I under the heading of the statics of ferromagnetism. Section II is concerned with the dynamics of ferromagnetism. The chief phenomena in which time plays a significant part are eddy currents and the various types of magnetic after-effects. Losses in a ferromagnetic material may arise from hysteresis, eddy currents and after-effects. Usually, all three are involved and special techniques are required to disentangle them. With suitably subdivided specimens, eddy currents can be reduced, and with specimens of appropriate form their effects can be calculated. By decreasing the amplitude of the field the hysteresis effect may be made small in comparison with the after-effects. The latter are due to the retarded restoration of a thermodynamic equilibrium, disturbed through the agency of an external force, and are attributable to a process of diffusion of heat or of material particles characterised by a "relaxation" time. A related effect, termed by the author "disaccommodation," manifests itself in a sharp rise in the initial permeability in response to a change in the magnetic field followed by a gradual and continuous decrease with time. A new approach to these problems is outlined and their practical importance is stressed.

In 1933, the author began a systematic study of the copper, magnesium, manganese and nickel zinc-ferrites, now known under the trade name "ferroxcube." Their properties as core materials, which include exceptionally low hysteresis and extremely low loses at high frequencies, are fully discussed in Section III, together with the properties of certain magnet steels.

In view of the conditions under which this monograph was produced the occasional misspellings and peculiarities in English are excusable. Much of the theory is still in the tentative stage, capable of giving orders of magnitude rather than quantitative agreement with experimental findings. Now that work under more nearly normal conditions is possible, it is to be hoped that Dr. Snoek will continue these investigations, so rich in promise of scientific interest and technical application.

Breathing in Irrespirable Atmospheres. By SIR ROBERT H. DAVIS, F.R.S.A. The Saint Catherine Press, Limited, 29, Great Queen-street, London, W.C.2. [Price 25*s.* net.]

THIS country owes most of its knowledge of industrial respiratory appliances, mine-rescue apparatus and deep-diving dress to the firm of Siebe, Gorman and Company, and Sir Robert Davis, their managing director, has devoted a lifetime to the study and production of apparatus which allows people to breath safely in harmful or even lethal conditions. His initiative, faith, and patient research have led to the development of modern breathing appliances of many types, and his new book is the first publication which gives an authoritative and comprehensive account of all aspects of the subject. Courage is no proof against oxygen-want or noxious gases, and breathing apparatus should be used whenever it is necessary to rescue men who have become unconscious in mines, sewers, burning buildings, chemical works, unventilated storage tanks, etc.

After an intriguing chapter on the use of poison gas in the animal world, and an interesting historical review of the development of gas and incendiary warfare, the author gives a concise explanation of the human respiratory and circulatory systems, causes and indications of oxygen-want, and the effects of gas poisoning. The physiology of respiration is treated simply and in a manner which the engineer will understand and appreciate; in fact, the subject matter of the whole book is so interspersed with amusing historical notes, comments, and excellent illustrations, that the sombreness of the subject is subdued by interest. This is no glorified catalogue, although the descriptions and illustrations of Siebe, Gorman and Company's respirators, self-contained breathing apparatus and resuscitation apparatus naturally occupy the greater part of the 386 pages. The evolution and development of the various types of breathing appliances are dealt with in a manner which reflects the enthusiasm that Sir Robert Davis has in his life's work, while the amount of detail given will satisfy all those who have to provide protective measures for personnel who may encounter dangerous gases in the course of their employment.

Appliances and methods for the treatment of poisoning, electric shock, drowning and asphyxiation are all admirably illustrated and described. Separate chapters are devoted to specialised work, such as that of the mine-rescue brigades, who are trained in the use of self-contained breathing apparatus so that they may be ready to go to the rescue of fellow miners and deal with any material damage caused by underground explosions of gas or coal dust. The breathing problems of high-altitude flying are also dealt with, and there is a section describing and illustrating modern gas masks and gas-detecting devices. Although several of the appliances described in this book have been developed for wartime purposes, the subject matter is chiefly concerned with their employment for the humanitarian purposes of protection against noxious and poisonous gases, dust, heat and fire.

OIL REFINING IN MANCHESTER.—To mark the completion of ten years of oil-refining operations in Great Britain, Messrs. Manchester Oil Refinery, Limited, have published a booklet entitled "The First Ten Years." This gives a description of the refinery, with numerous reproductions of photographs of various aspects of the plant and equipment, and a pictorial flow chart of products of the refinery. Copies are obtainable on application to the Public Relations Department of the firm, 10 Dover-street, London, W.1.

WOVEN PLASTIC MATERIAL.—A new woven material, to be known as Tygan, will shortly be placed on the market by Messrs. Fothergill and Harvey, Limited, 37, Peter-street, Manchester. The yarn from which this material is made is based on synthetic resin compounds, and has been developed by BX Plastics, Limited, Larks Hall-road, London, E.4, under the name of Bexan. It is produced in flexible filaments in gauges between 0·010 and 0·012 in., with a strength of 25,000 lb. per square inch, and can be built-up into various weaves which are particularly resistant to weather conditions, including those encountered in the tropics, as well as to moisture, acids, alkalies, micro-organisms and bacteria. It is also stainproof, and grease and oil are easily removed from it. Its direct engineering applications are few, but there are some subsidiary uses to which it may be put.

SURFACE ANALYSIS WITH PLASTIC REPLICAS.

By A. J. CHISHOLM, B.Sc.(Eng.), A.M.I.Mech.E., and J. M. LICKLEY, B.A.

SURFACE analysers of the stylus type used for the measurement of surface roughness are becoming common instruments in machine shops and metrology laboratories. Their advantages lie in their wide sensitivity range, in the completeness of the information which they provide, and in the ease and rapidity with which they can be used upon suitable specimens. On the other hand, their use is limited to the inspection of those specimens which are accessible to the particular type of pick-up used. Stylus traverses over large machined faces, curved surfaces or surfaces such as the journals of crankshafts cannot be made unless special additional apparatus is available. Moreover, measurements on surfaces such as these are often tedious and troublesome. A technique has been now developed, however, in which plastic replicas are made of the test surface and measured with the surface analyser.

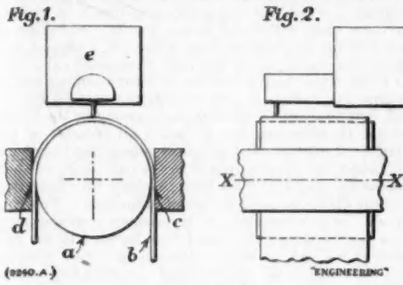


Fig. 1.

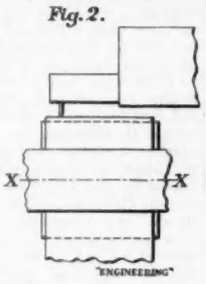


Fig. 2.

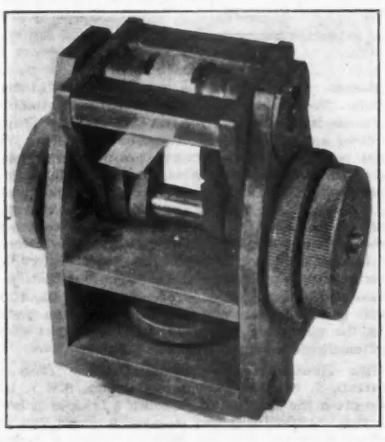
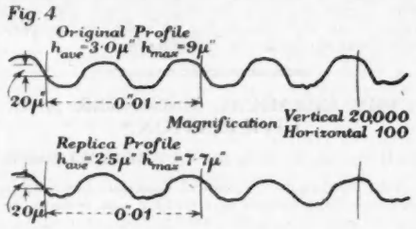
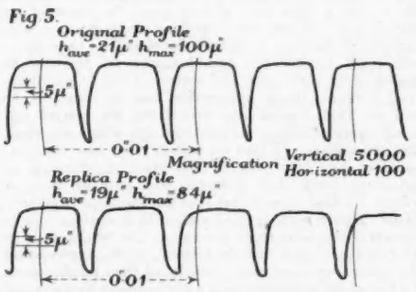


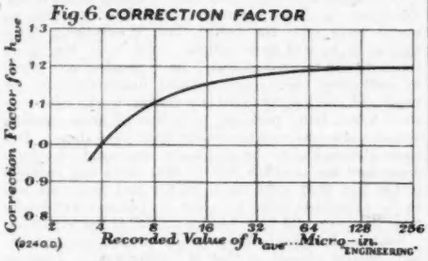
FIG. 3.

The moulding technique for making the replicas has been fairly well established in the past, but the replicas have been examined only by optical means and not with a stylus. The intensity of light transmitted through the replica is affected by the irregularities on the replica surface. Measurements of light transmitted through the replica are either made directly,* or, alternatively, the replica is oscillated laterally in front of a light source and the variations in transmitted light detected by a photo cell, the average variation in the resulting current being used as a measure of the roughness of the specimen.† Such indications of roughness are not always satisfactory; the first method is relatively insensitive, while the second method gives no measure of the surface profile and is therefore liable to serious misinterpretation.

Experiment shows that cellulose acetate is the most satisfactory of a number of materials which have been tried for making the replicas; it is used in the form of transparent polished sheets 0·020 in. thick. The solvent solution used for softening the contact side of the replica strip contains cellulose acetate dissolved in acetone and diacetone alcohol in the following proportions: 100 c.c. acetone, 10 c.c. diacetone alcohol, and 7 grams cellulose acetate. The cellulose-acetate sheet is cut into strips of a convenient size, about 4 in. by $\frac{7}{8}$ in. The test surface is cleaned with trichlorethylene and then with acetone, and a few drops of the solvent solution placed on it. The plastic strip is then pressed firmly into contact with the surface with one stroke of a soft-rubber roller. After 20 minutes the replica is peeled off, and a similar drying period is allowed before examination of it is made with the surface analyser. In measuring the roughness of a plastic replica the chief difficulty lies in keeping the replica free from extraneous waviness. This waviness can be caused either in the preparation of the replica, or in mounting it before examination. The moulding process described above and the simple method (patent applied for) which has been developed for mounting the replica largely overcome these effects.







The principle of the mounting method is illustrated in Figs. 1 and 2. The cylinder *a*, with the replica strip *b* placed over it face upwards, is pressed into a rectangular slot of which the plane surfaces *c* and *d* are parallel to the axis of the cylinder. The distance between the surfaces *c* and *d* is arranged so that an interference fit is produced on the replica strip. The replica is thus stretched taut and conforms closely to the surface of the cylinder. If care is exercised initially in making the cylinder, the replica is in this way mounted free from wavy mess, and straight-line traverses can be made on it parallel to the axis of the cylinder. It has been found that a skidless type of pick-up is most suitable for these measurements. The photograph reproduced in Fig. 3 shows the mounting block with its special stand for aligning it accurately on the base plate of the surface analyser. The cylinder is pressed into the slot by means of a link mechanism operated by large knobs at each end of the apparatus.

Errors in measuring surface roughness in this way are due mainly to the shrinkage of the replica during setting of the cellulose acetate. Values of the average roughness $h_{ave.}$ and the peak-to-valley roughness $h_{max.}$ obtained from the replicas are low, but the profile trace retains most of the characteristics of the original surface, the most noticeable effect being a blunting of the peaks. The error caused by bending a flat replica around the mounting cylinder is estimated to be of the order of only 3 per cent. A comparison of the replica and original profile records of an N.P.L. glass roughness standard is shown in Figs. 4 and 5, the former illustrating the fine standard and the latter the coarse. Measurements on a number of surfaces have enabled a correction curve for $h_{ave.}$ to be drawn with an accuracy of $\pm$ 10 per cent., and this is given in Fig. 6. Somewhat greater errors occur in the estimation of $h_{max.}$ Since variations in roughness greater than this error of $\pm$ 10 per cent. very often occur over the same surface it is considered that this accuracy of reproduction is satisfactory for most purposes.

This technique has been applied successfully in particular to surface-roughness measurements of thrust-bearing faces and journals of large turbine spindles, and to the tooth flanks of gear wheels. It has also been possible* to extend the technique for use on complicated surfaces which are inaccessible to a surface analyser pick-up and are too small for the standard process described above to be used. One face of a solid block of cellulose acetate is made to conform accurately with the test surface. This block is then used instead of the cellulose acetate strip and the standard moulding procedure adopted, a static load being used for applying pressure in place of the rubber roller. A mounting block is unnecessary in these cases.

In addition to enabling measurements to be made on surfaces which cannot be measured in any other way, it is thought that the method described is of value to those whose needs in this field are limited and do not justify the purchase of a surface analyser of their own. In such cases, replicas can be made of any surface which they wish to inspect and these can subsequently be measured at a central metrology laboratory. Technical colleges are probably well suited to undertake such a service.

The investigations described above were carried out by the authors in the Research Department of Messrs. Metropolitan-Vickers Electrical Company, Limited, of which Sir Arthur P. M. Fleming, C.B.E., D.Eng. is Director of Research and Education, and Mr. B. G. Churcher, M.Sc., M.I.E.E., is manager.

* ENGINEERING, vol. 158, page 437 (1944).

† H. K. Herschman, *Mech. Eng.*, vol 67, No. 2, page 119 (1945).

SWEDISH PIT PROPS FOR BRITAIN.—Three-fourths of Sweden's exports of pit props in 1947, namely 144,558 cub. m. (5,059,500 cub. ft.) out of a total of 197,171 cub. m. (6,904,500 cub. ft.) came to Great Britain. The bulk of the remainder went to the Netherlands.

DATA ON ALUMINIUM ALLOYS.—A new edition of their "Noral Data Sheet" has been issued by the Northern Aluminium Company, Limited, Banbury, Oxfordshire. The first edition of the data sheet was produced in November, 1945, and over 10,000 copies were issued in the subsequent two years. Printing was restricted to batches of 1,000 copies so that figures could be brought up to date as occasion arose. The general form of the new edition remains unaltered and consists of a large folder having, on one side, tabulated particulars of the composition and properties of the firm's wrought alloys and alloys for casting; on the other side there are general notes on aluminium and its alloys.

THE LATE MR. F. G. GUDGEON.—We note with regret the death of Mr. Frederick Gerald Gudgeon, which occurred at his home in Derby on April 5, at the early age of 51. Mr. Gudgeon, who was works manager of International Combustion Limited, Derby, received his technical education at the Manchester College of Technology, and also at the Polytechnic, London, and served his apprenticeship with Metropolitan-Vickers Electrical Company, Limited, Manchester. From there, in 1926, he went to Messrs. Daniel Adamson, Limited, Dukinfield, for a short time, and then joined the Underfeed Stoker Company, Limited, at their London office. In 1930, he was transferred to the Derby Works of the firm, which, by then, had been merged into International Combustion Limited, and, some years later, was appointed works manager. Mr. Gudgeon, who served in the Royal Fusiliers and the Royal Flying Corps during the war of 1914-18, was a capable technician and possessed great administrative ability. He was elected a member of the Institute of British Foundrymen in 1937 and of the Institution of Mechanical Engineers in 1938. He was also a member and a past-president of the Derby Society of Engineers, and took great interest in the Derby Technical College.

LOCOMOTIVE RUNNING DEPARTMENT.

A REPORT of a conference of locomotive shed masters, which was held from March 31 to April 2, 1948, at the St. Ronan's Staff Training Centre at Hadley Wood, has been received from the Eastern and North Eastern Regions of British Railways. Papers were read on various aspects of the work of the locomotive running superintendent's department, and each was followed by a discussion. Mr. L. P. Parker, O.B.E., M.I.C.E., M.I.Mech.E., locomotive running superintendent, Eastern Section, presided at both the opening and closing sessions. A summary of the points of engineering interest is given below.

In a paper on "Turn-round of Engines," Mr. D. W. Harvey, locomotive shed master, Norwich, suggested ways and means of reducing the time required for this operation. Passenger engines usually arrive at, and depart from, a shed according to a fixed time-table or "diagram," and for this reason there is little opportunity of saving time, but freight engines offer more scope. The author recalled that during the war, at Woodford and Hinton, engines hauling coal and Government stores to and from the Great Western Railway, were regularly returned to traffic in 45 minutes. Between three and five hours were normally required to raise steam to 50 lb. per square inch from cold, but it was interesting to note that on the London Midland Region it was the practice to allow eight hours for filling up and raising steam. The time may be reduced by washing out and filling up with hot water, or by "pre-steaming," i.e., blowing high-pressure steam into the boiler from a stationary boiler. Regarding the washing-out of boilers, the period between successive "wash-outs" was generally about six or seven days, although in Scotland, where the water was very soft, the period was between a fortnight and a month. In the former case, in a week of six working days, no less than 32¼ hours (22·5 per cent. of the total time) were spent in changing or "blowing down" the boiler water.

Mr. Raymond Gomersall, technical assistant to the locomotive running superintendent, Eastern Section, presented a paper on "The Planned Servicing System." He remarked that, in practice, they had no difficulty in getting an engine off the road for servicing; their principal task was to ensure that the time was used to the best advantage, to prevent, rather than cure, troubles, and to ensure that the engine did not fail during its period in traffic until the next servicing. This period had been fixed at a fortnight. It coincided with the fortnightly boiler examination, when the time required for the boiler to cool down could be used for other purposes. In order to avoid reducing the availability of a locomotive, repairs which could safely be deferred should be allowed to accumulate during the fortnight. Schedules of the common defects of each type of locomotive were used to aid inspection. A three-shift system was in operation. A charge hand on each shift controlled two gangs: a "servicing gang" and a "maintenance gang." The servicing gang dealt with items on the fortnightly schedule, and the maintenance gang carried out jobs which were done at longer intervals, repairs which had been allowed to accumulate, etc. In order to save engine-hours, it was essential to concentrate the men on one engine at a time. Partly as a result of the introduction of this scheme at Norwich, many B1-class 4-6-0 locomotives had completed over 100,000 miles before they required a first "general" repair. The engine-miles between casualties were 58,700 for passenger engines and 75,372 for freight engines; these figures were considerably greater than the corresponding figures for all engines on the Eastern Section during 1947.

In presenting a paper on "Engine Availability," Mr. G. Ford, assistant district locomotive superintendent, Stratford, said that if the figure of 9·45 per cent., which represented the proportion of engines waiting for material and under and awaiting repairs, could be reduced to 7 per cent., the number of locomotives available on the Eastern Section would be increased by 28. Mr. R. D. Gardiner, M.B.E., in a paper on "Regular Engines," said that engine availability was improved by allocating two or three engine crews to each engine, these crews, and none other, to man the engine from the time it left the main works until its return for repairs. This is a partial return to the old system, common before 1914, of one engine—one crew; but the advantage of 24-hour operation has been retained by employing two or three crews to each engine. There were many advantages of this latest system. Engines were kept cleaner, the daily examination by the driver was more thorough, small adjustments were carried out, drivers reported defects more accurately, and followed up the repairs, they paid more attention to the custody of tools and the consumption of oil, and, by "knowing" the engine, they drove it more efficiently. Important advantages also accrued to the operating department. Engines were in better condition, more certain of leaving the shed and arriving at the train on time, and drivers were keener to work punctually. A spare engine should be kept for the crew whose engine was off the road for a fortnightly servicing.

Mr. C. H. Hewison, A.M.I.C.E., technical assistant to the locomotive running superintendent, Eastern Section, presented a paper on "Some Recent Developments on the Eastern Section." While making a further reference to the regular engine scheme, he said that, in the Eastern Section, by the careful preparation of engine operating diagrams and engine-men's hours of duty, and by consultation with the footplate staff, every main-line passenger engine in the Eastern Section was now worked by regular crews. Mr. Hewison said that they were now using electric motors and conventional rollers for turning wheels for setting valves. They were re-setting valves at every 20,000-miles examination. Trials were being carried out with a Shell-Mex proprietary product, known as Ensis 256, for preserving the polished surfaces of valve gears, spare parts in stores, etc. Owing to trouble experienced with spring fractures, experiments were also being carried out with penetrating oil containing graphite which was applied to the spring leaves.

THE CHEMICAL ENGINEER AND CIVILISATION.*

By H. W. CREMER, M.Sc. (Lond.), F.R.I.C., M.I.Chem.E.

THE Institution of Chemical Engineers has been in existence for a quarter of a century, and perhaps, on that account alone, a little introspection—even philosophising in a mild sort of way—may be regarded as permissible. There are doubtless many reasons why our earlier chemical industries developed as they did—somewhat haphazard, and bringing in their wake pollution of earth, sky and water. Only in comparatively recent times apparently has it come to be realised that similar operations can be carried out much more efficiently in surroundings which are clean and wholesome. I like to believe that the chemical engineer has been one of the chief instruments in bringing about that desirable and happier state of affairs. I also believe that it is the chemical engineer's blend of pure with applied science that enables him to translate the laboratory process to the works scale in an intelligent and orderly fashion, while appreciating the consequences of his actions in all their implications.

One might have supposed, with the many unspeakable examples we have before us, that later generations might have seen the light; but, if anything, they appear to be still more callous. Not once, but many times during the recent war, I have pleaded with those in authority that some natural feature should be preserved and incorporated in a general works lay-out—some green lane, perhaps, or a line of trees running across a site—as could so easily have been done. But these things had to be ruthlessly destroyed, the bull-dozer and the dragline had to take their toll, in spite of the fact that more time, energy and materials had to be expended later in order to conceal artificially what Nature could have hidden so well if left to herself.

Seldom, I suppose, has any one term in our vocabulary been so abused as that of "planning." Torrents of words on the subject are poured forth daily upon a far too tolerant and complacent public whose power to criticise effectively seems to become more and more atrophied with the passage of time. One of the chief dangers of our era seems to be that the planners do not co-ordinate their efforts and agree among themselves. I suggest that there is a great opportunity for the chemical engineer to bring his influence to bear on the problem, in order that industrial planning may be considered as a whole and not piecemeal. Too often has the latter prevailed, with material and spiritual losses to the nation which are quite incalculable. Modern industry requires imagination; it needs, for one thing, a consideration of the results of operating a process. I am concerned lest the present great urge to "develop" our Colonies, Protectorates and the like may result in the same haphazard growth of industry and subsequent desolation as have followed in its wake in the home country—townships ravaged by fumes from chemical works, rivers polluted, mineral resources unwisely exploited, and so on. Every aspect and implication of setting up industries where none has existed before should be taken into account in advance, for only thus can the new industrial world be made better than the old. In that, I earnestly believe, the chemical engineer can exercise a profound influence. The chemical engineer has come to be regarded—and I believe rightly so—by those who know him intimately, as a person who sees things clearly and sees them whole. Few other professions have taken such trouble to create in the minds of their initiates such a blend of the pure and the applied sciences, such an appreciation of good and bad, where manufacturing technique is concerned, and to equate these with that knowledge of mankind and its habits without which a really balanced judgment cannot be achieved, nor that forward looking which the makers of industries have all too frequently lacked in the past.

If what I have said of the responsibilities of the chemical engineer are true, the responsibilities of his teachers are even greater. The development of university and college courses in chemical engineering in this country has been despairingly slow, but the signs are that, at long last, the subject has come to be regarded as wholesome and decent. Should it be thought that I speak with bitterness, I have just cause to do so, for I have had much personal experience of the protracted and tortuous negotiations which hitherto have so often been necessary in order to establish new courses of chemical engineering in this country, and of the prejudices which have delayed them. The result is a most embarrassing dearth of young chemical engineers, which the temporary expedients at present in force cannot by any means rectify. Speaking as one who for 20 years has been a teacher, I suggest that there is a tendency on the part of modern exponents to make rather heavy weather of their teaching and to neglect instruction in the refinements of civil life. I feel that teachers of chemical engineering in the future should be recruited, not so much on account of the number of scientific and technical papers they may have published, but having regard to the catholicity of their knowledge and above all their capacity for inspiration and the ability to instil a sense of proportion. Teachers should be remunerated in a manner commensurate with their attainments, and I look forward to the day when it will not be left to altruism to decide whether academic life shall be enriched by scientific minds which have been previously ripened and matured in an industrial environment.

* Presidential address delivered before the Institution of Chemical Engineers, on Friday, April 16, 1948. Abridged.

CONTRACTS.

MESSRS. GILBERT GILKES AND GORDON, LIMITED, Kendal, Westmorland, have received a contract for hydro-electric equipment for the City of Lhasa, capital of Tibet and situated 12,000 ft. above sea level. The plant will include six 125-kW low-fall vertical-shaft water turbines which will drive, through totally-enclosed oil-lubricated speed-increasing bevel units, to be supplied by MESSRS. DAVID BROWN AND SONS (HUDDERSFIELD), LIMITED, horizontal shafts directly-coupled to 125-kW 400-volt three-phase 50-cycle alternators. The latter are to be furnished by MESSRS. LAURENCE, SCOTT AND ELECTROMOTORS, LIMITED. The remote situation of Lhasa and the difficulties of access through the Himalayan passes have imposed limitation on the design; thus the maximum weight of any single part of the equipment is one ton.

THE DEMOLITION AND CONSTRUCTION COMPANY, LIMITED, 3, St. James's-square, London, S.W.1, have been given the contract to demolish a brick-arch bridge carrying a disused tramway over the Swansea Vale line, British Railways (London Midland Region), between Swansea, St. Thomas and Upper Bank stations. The work will be carried out at week-ends in order to minimise interference with traffic.

MESSRS. LEONARD FAIRCLOUGH, LIMITED, Terminal House, Grosvenor-gardens, London, S.W.1, are to build a new steel and concrete bridge over the main line, British Railways (London Midland Region) at Ivy-lane, Berkhamsted, Hertfordshire, to replace a temporary foot bridge built in place of the original bridge destroyed by enemy action in November, 1940.

ALTERNATING CURRENT IN AIRCRAFT.—The "Seagull" single-engined monoplane amphibian flying-boat, built for the Navy to replace the "Walrus" and "Sea Otter," is equipped with a main-engine driven electric-generator, which during normal cruising provides a 200-volt, three-phase, 400-cycles per second supply, and also an 80-volt single-phase supply at 1,600 cycles per second. This is a development in the application of alternating-current power to aircraft electrical systems, as hitherto, the question of alternating-current supplies has generally arisen in connection with large aircraft. In this instance, however, one of the main reasons for using alternating-current in a comparatively small machine was to provide electrical power in a form which would keep the wing-flap mechanisms in close synchronism. There is no mechanical linkage between the port and starboard flaps, these being operated by low-slip squirrel-cage induction motors fed by the 200-volt three-phase supply. In practice the supply frequency is proportional to the speed of the main engine, which is a Rolls-Royce "Griffon," and this has a total speed range of 1·8-1·0. A 28-volt direct-current supply using frame-return and an auxiliary 28-volt three-phase 400-cycle per second supply are obtained from a three-phase transformer-rectifier unit.

THE MANUFACTURE OF FLUORESCENT ELECTRIC LAMPS.

In 1939, the General Electric Company, Limited, Magnet House, Kingsway, London, W.C.2, were asked by the Ministry of Aircraft Production to purchase a suitable building in the Manchester area, where radio valves and other thermionic apparatus could be manufactured on behalf of the Government. A disused four-storey cotton mill was consequently acquired at Shaw, near Oldham; and, after the necessary adaptation and equipping with specialised plant had been completed, production was begun in 1941. Between that date and the end of the war, over 7,000,000 radio valves and cathode-ray tubes were made for the services and, when the demand for this apparatus decreased, a change-over was made to the quantity production of flourescent lamps. As part of the policy of securing diversity in areas where previously industrial activity had been specialised, the manufacture of valves was also continued on a small scale. In addition, certain types of incandescent lamps were made. This conversion has now been practically completed; and we were recently given an opportunity of inspecting the methods employed in the manufacture of what is becoming an increasingly popular method of illumination.

Views in the factory, which are referred to in detail later, will be found on page 396. It may, however, first be recalled that the ordinary fluorescent lamp consists essentially of a glass tube, 4 to 5 ft. long, which contains argon at low pressure, as well as a small globule of mercury. The inner surface of this tube is covered with a fluorescent powder and an electrode coated with electron-emitting material is sealed into each end. These electrodes are connected to contacts in a terminal cap, through which the operating current is passed from the supply mains. As the potential necessary to start a discharge in such a tube is well above the normal supply voltage, it is connected to a choking coil and the electrodes are first heated to the required temperature by closing a starting switch. The switch is then opened, so that a momentary high voltage is induced across the tube terminals by the action of the choking coil. As a result, a building up of ions occurs in the discharge space, and this build-up is accelerated by the pressure of the argon. The mercury is vaporised and light of a characteristic colour is emitted. Considerably more emission, however, takes place in the ultra-violet region of the spectrum and is converted into luminous radiation when it falls upon the fluorescent powder. The resulting light is generally markedly coloured, so that to obtain a spectral composition suitable for general use, mixtures of two or more of the powders, known as phosphors, are commonly employed. For instance, a mixture of magnesium tungstate and zinc-beryllium silicate is employed when white light is required. All these phosphors have the common characteristic that they are excited by the mercury ultra-violet line at 2,537 Å.

The fluorescent lamps manufactured at Shaw are of the 80-watt and 40-watt types, the tubes being repectively 5 ft. and 4 ft. long. Owing to the increasing demand for these, quantity production methods can be efficiently employed in their manufacture. Lamps, 3 ft., 2 ft. and 18 in. long have, however, passed the experimental stage and are being manufactured at the Wembley works of the company. They should be available for the non-industrial market in a few months. Circular patterns, suitable for use in table and floor standards, may also be expected in the near future. In this connection, it should be noted that a primary consideration in determining the dimensions of fluorescent lamps is that they must be capable of operation from 200- to 250-volt mains. It is also essential for stable operation that the tube voltage should not be greatly in excess of 60 per cent. of the supply voltage. The difference must be absorbed in a ballast, which generally consists of an inductive impedance, and is therefore larger the shorter the tube. It is also necessary to use a larger capacitor, in order to correct the lower overall power factor which results from the employment of the larger impedance. From the points of view of efficiency, light output and control gear, it is therefore desirable to use the longest tube consistent with stable operation.

Both the 80-watt and the 40-watt lamps are designed to emit either daylight or warm-white light and for operation on alternating current circuits, in conjunction with the appropriate auxiliary gear, which is made at other works of the company. They can also be operated on direct-current in conjunction with a series resistance, although the overall efficiency is less. As regards performance, the current consumption of an 80-watt lamp is 0·85 ampere and of a 40-watt lamp 0·41 ampere. The lumen output, after 100 hours burning, is 3,600 and 2,000, respectively, giving efficiencies of 45 and 50 lumens per watt. About four times as much light is therefore obtainable from a fluorescent lamp as from a tungsten lamp of the same current consumption. The light output falls off by about 10 per cent. during the first 100 hours of use and by about the same amount during the remainder of the lamp's life. The reason for this is not completely understood, but the main cause seems to be the interaction which takes place between the excited mercury atoms and the crystalline surfaces of the fluorescent powder. A subsidiary reason is that deposition of metallic mercury and alkaline earth metals from the cathode occurs on the fluorescent coating. This depreciation, however, has been largely counteracted recently by the use of materials, such as calcium halöphosphate, as the fluorescent powder. The amount of ultra-violet energy emitted depends to a large extent on the vapour pressure of the mercury and the current density. If either of these is increased above a certain optimum value the amount of ultra-violet energy which reaches the walls of the tube decreases. The optimum wall temperature for most tubes is about 40 deg. C., which corresponds to a mercury vapour pressure of 0·006 mm. On the other hand, the efficiency with which ultra-violet radiation is produced increases as the current density is decreased, provided the vapour pressure of the mercury is maintained at its optimum value. Very low current densities, however, would not be economic. Moreover, their use would make it impossible to maintain the tube at the optimum operating temperature under the usual ambient conditions.

Turning to the manufacturing methods employed at Shaw, the glass tubes, which are made by automatic machinery at the Osram glass works at Wembley, are delivered cut to length and are dried and cleaned internally before use. A view of a stock of such glass tubing stacked ready for use is given in Fig. 1, on page 396. The various types of fluorescent powder, which have been developed in the company's research laboratories, are delivered in a coarse state and after being mixed with butyl acetate are placed in earthenware jars containing silica pebbles. These jars are then rotated on rollers for about three hours, after which their contents are emptied into metal drums, nitrocellulose being added to act as a binder and camphor to assist in the flow of the thin creamy mixture which results. The drum is then rotated on the rollers for about half an hour, at the end of which time the mixture is passed through a 200-mesh sieve and is ready for deposition on the interior of the glass tubes. The proportions of powder and binder must be correct to within narrow limits, in order to ensure uniformity of the coating thickness. The viscosity is also tested at frequent intervals, as any variation would affect the adhesion of the powder to the tube and thus the operating efficiency of the lamp. The mixture is then emptied into a 10-gallon tank, which forms the base of the filling machine illustrated in Fig. 2, on page 396. The cover of this tank contains a number of holes, fitted with rubber gaskets, into which the tubes are inserted, as shown in the same illustration.

The fluorescent mixture is then forced up the tubes to the required level by admitting compressed air into the top of the tank. When this pressure is released the mixture recedes leaving a film of powder and binder adhering to the glass. After a short interval for drainage, the tubes are next placed in a drying oven where they are heated by warm air for about 30 minutes. The fluorescent coating is thus caused to adhere to the tube sufficiently firmly to prevent detachment during subsequent handling. The tubes are then stamped with a silver nitrate paste to show the trade mark and other relevant details and are heated in a radiant-heat oven for about 15 to 20 minutes. During this process, the binder is decomposed and evaporated, so that only a thin dry coating of fluorescent powder is left on the internal surface of the tubes. The tubes are then taken on a conveyor to a position in the factory where the quality of the coating is checked. About 1½ in. of this coating is next removed from each end by the insertion of motor-driven rubber pads. The motors driving these pads are mounted on carriages and are brought into position at each end simultaneously by depressing a pedal. This operation is illustrated in Fig. 3, on page 396. The completed tubes, which are visible in the background of the same illustration, are now ready for the insertion of the electrode assemblies.

These assemblies are of the same general design as the "pinches" which form part of an ordinary electric lamp. They are built up from glass tubing, on one end of which a flange is formed. This operation is carried out on an automatic machine consisting essentially of a capstan which revolves about a vertical axis, and round the periphery of which a number of chucks are arranged. In the first position on this machine, the bottom of the tube is heated sufficiently to soften it. It is then flanged out in a second position by a rotating mechanism, the principle of which is similar to that of a centrifugal governor. In the succeeding position the tube drops down to a stop, so that the length of the flanged portion is controlled and is then slightly heated, so that the latter can be cut off from the parent material by two rotating knives. The detached flanged portion slides down a chute, is picked up by the teeth of a wheel revolving on a horizontal axis and passed to an annealing furnace.

The flange, the glass supporting rod on which the electrodes are mounted, the small glass tube, through which the air is exhausted and mercury and argon introduced, and the leading-in wires, are then assembled on "pinching machines." The leading-in wires consist of a length of copper through which contact is made with the plates in the terminal cap; a length of copper-plated nickel-iron where they pass through the glass seal; and a length of nickel wire inside the tube, by which connection is made to the electrodes. The pinching machines, which are automatic in operation, also comprise a capstan round the circumference of which a number of jigs are mounted. The leading-in wires are fed into these machines by hand while the glass flanges, supporting rods and evacuating tubes are picked up from hoppers by oscillating chutes. As the machine moves in steps through the various positions, these components are assembled, while the lower part of the flange and the top of the supporting rod are heated by air-gas flames so that they gradually become plastic enough for the glass to adhere to the leading-in wires. The flange is then pressed by metal moulds into a spatulate form and the glass supporting rod is fixed in position. While the glass is still soft a puff of air is blown through the exhaust tube to clear it and the completed pinch is then passed through several cooling positions before it finally leaves the machine.

During the next operation the nickel ends of the leading-in wires are bent to the required shape in a jig, the tungsten cathode coil is secured in position on them and the nickel-iron anode plates are spot welded to extensions of the leads. The cathodes are now coated with a mixture of barium and strontium carbonates in a nitro-cellulose binder to provide the electronic emission, the binder being subsequently decomposed by passing a current through the electrodes. These operations are carried out on the benches illustrated in Fig. 4, on page 396. The completed assemblies are then placed in the heads of a rotating mechanism and the ends of the glass tubes, which have been prepared in the way already described, are placed over them. The tube is next heated by gas jets so that it diameter is reduced and it is welded on to the flange, the surplus glass falling away. The tubes are then exhausted in stages by a mercury-vapour pump system, which produces a high vacuum, and are heated during the process to a temperature of about 400 deg. C., so that any occluded gases are removed from the glass. At the same time, the cathodes are heated by a progressively increasing current to activate the emissive coating, the gases thus freed being also removed by the pumps. A small quantity of mercury is then injected by a foot pump through the small tube, the interior of which is frosted to prevent the adhesion of the metal, and, finally, a little argon is introduced and the tube itself sealed off. One of the machines on which these operations are carried out can be seen in the background of Fig. 5, on page 396.

The lamps then pass down a conveyor to the capping machine. This is loaded with brass caps, which have been previously filled with cement, and, as mentioned above, are either of the bayonet joint or bi-pin pattern. The leading-in wires are threaded through the caps by hand and the latter are loosely secured to the tube and with it are placed on the first of a series of peripherally arranged jigs. Each tube then passes successively through a number of gas flames, which gradually heat up the cement in the cap. The ends of the leading-in wires are cut off flush with the contacts, the latter being exposed to a puff of compressed air to remove any excess copper. A little soldering flux and a pellet of solder are then applied to the latter and heated by an electric iron. When the solder has set, the tube is turned end for end and the same series of operations repeated on the other cap. The completed lamps then pass to an "ageing" rack where current is applied for about 30 minutes to stabilise them. They are finally taken to the test table illustrated in Fig. 6, on page 396, where they are subjected to routine electrical and physical examinations. In particular they are tested to ensure that they will strike at 185 volts and that the capping and soldering have been properly carried out.

In conclusion, it may be remarked that, apart from the technical control of processes and materials, the major problems in conducting the quantity production of fluorescent lamps centre round storage and transport, since overall economy can only be obtained by continuity of operation. The specialised machinery employed also demands an uninterrupted supply of material and the equally prompt removal of the finished work. The widely different times required by the various processes introduce their own complications and necessitate the careful organisation of the entire programme of manufacture.

GRINDING DOVETAIL SLIDEWAYS OF MACHINE TOOLS.

Messrs. Arthur Scrivener, Limited, Tyburn-road, Birmingham, have been grinding the slideways of machine tools with profiled cup wheels for over five years. The method, which has been patented in this country and the United States, offers several advantages over the older and more commonly used methods, namely, peripheral-wheel grinding, and cup-wheel grinding, using the rim. A machine set up for grinding with a profiled cup wheel is shown in Fig. 1.

When grinding a slideway with the periphery of a wheel, a considerable amount of metal can be removed in one operation, this having the advantage that a considerable tolerance can be allowed in the preceding machining operation. There is, however, a risk of distorting the metal due to local heating. Furthermore, the method is only applicable to slideways which permit the wheel to run off at each end, and is not readily adapted to grinding dovetail ways. In cup-wheel grinding, the rim of the wheel is used, and the wheel is mounted on a spindle which can be swivelled so that the rim is at the required angle to the work. This method is more versatile than peripheral grinding, but it does not remove so much metal in one pass. Usually, it removes only sufficient to ensure alignment and accuracy, and it is therefore necessary to machine the surface accurately in the preceding operation. It is also more difficult to ensure accurate slideways, because it is customary for the axis of the wheel spindle to be give a slight tilt from the vertical position (or from the required angle), so that the wheel presents only its leading edge to the work instead of the whole surface of the rim. The central wheel in Fig. 2 shows the effect (exaggerated) of this method on the finished slideway: a series of very shallow hollows is produced. Many different cross-sections of slideways can be ground by this method, but it has the disadvantage that the wheelhead has to be swung and set to suit each angle. Thus, in the case of the slideway shown in Fig. 2, comprising a flat surface and two angular surfaces, three settings of the wheelhead would be required, as shown in the illustration. It is not usually possible to determine the accuracy of the setting angle closer than one minute of arc, even when using an optical clinometer, and any error due to this must be doubled on account of the corresponding tolerance on the grinding of the mating component.

When using a profiled cup wheel, as shown in Fig. 1, the rim and the periphery of the wheel grind the slideway. The main horizontal cross-slide of the machine carries a slide which can be set at any required angle, corresponding to the angle of the wheel periphery, and the moving member of this slide supports a swivelling mounting for the grinding-wheel spindle, which permits the spindle to be set vertically, irrespective of the angle of the slide. With this arrangement, **the axis of the wheel is vertical**, but the periphery of the wheel can be dressed by traversing the angular slide. The angle of the periphery corresponds exactly to the angle of the slide. Contrary to the opinion of advocates of conventional cup-wheel grinding, no difficulty is experienced with this method in using the whole of the cup-wheel rim for grinding flats and removing as much as 0·001 in. per pass. It is, however, necessary to use a machine of the portal type, as shown in Fig. 1. In this case, the grinding wheel is driven by a 3-h.p. motor. The particular advantage of this method is that, since the angle of the wheel is obtained with the wheel in a vertical position, the angles of both sides of the slideway (Fig. 2) after grinding are exactly similar. Similarly, the angles of both sides of the mating component are equal and correspond exactly to the angles of the female member. The angle of the dovetail slide may not be exactly 60 deg.—or whatever was intended—but this is unimportant, since the fit is perfect.

It will be apparent from the photograph of the machine reproduced in Fig. 1, that by traversing the table and the cross-slide, any number of dovetail ways can be created, either at right-angles to each other or parallel to each other, and on any number of horizontal planes, with the complete assurance that they can be correctly located and repeated, without any of the lengthy adjustments that have hitherto been necessary. In most machine-tool works there is a standard angle for the dovetail slideways, and in such cases it would obviously be advantageous to fix the angle of the wheelhead slide permanently by pinning it. The machine shown in Fig. 1 has been modified in this manner, with the slide fixed at an angle of 60 deg. Periodical inspections of the grinding machine have greatly reduced the necessity for routine alignment tests on the work. When, however, several different dovetail angles have to be produced, it is advisable to arrange for repeating the settings of the slide accurately and rapidly by locating pins or other suitable means.

The most important economies derived from this method of slideway grinding are obtained with small complicated assemblies rather than with large pieces such as machine tool beds. A typical case is that of a compound truing attachment for a centreless-grinding machine, consisting of four members fitted together, one on top of another, with three sets of slideways. The accuracy of the machine depends on the grinding of these slideways, and the upper member is required to deviate not more than 0·00005 in. in 8 in. The ways of this compound slide are ground in 6¼ hours by adopting the system which has been described. It is doubtful whether the slideways could be hand-scraped in less than 72 hours, even with a close machining tolerance and a highly skilled man for scraping

GRINDING DOVETAIL SLIDEWAYS.

MESSRS. ARTHUR SCRIVENER, LIMITED, BIRMINGHAM.

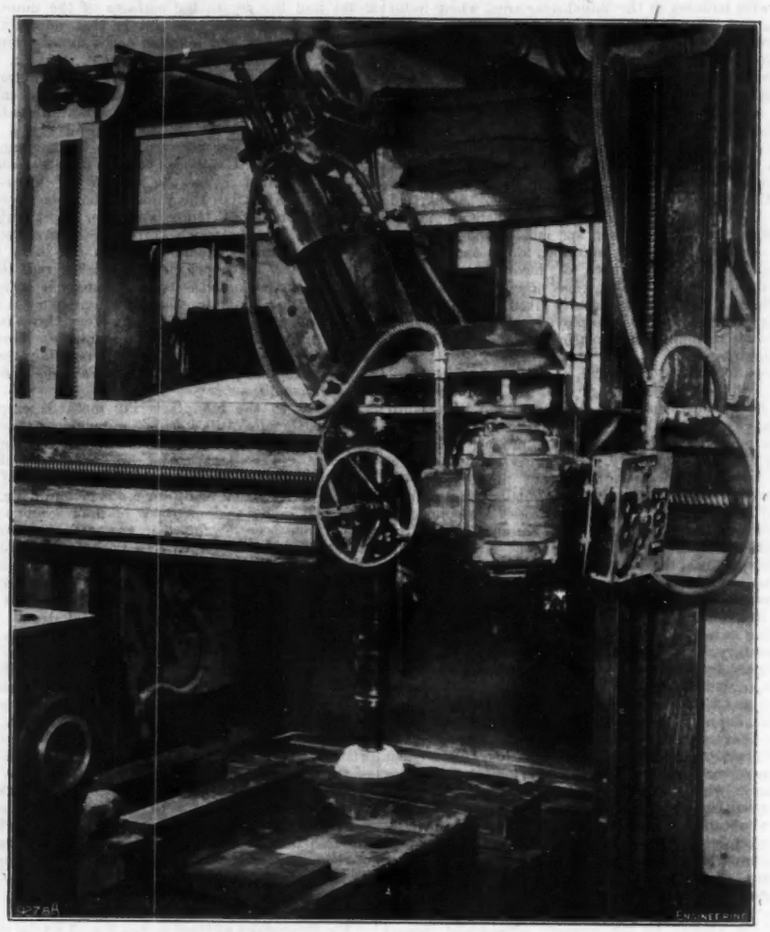
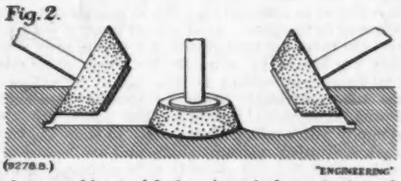


Fig. 1.

Fig. 2.



(9276 A.) "ENGINEERING"

Mechanical Handling Exhibition and Convention.—The first national Mechanical Handling Exhibition and Convention will be held at Olympia, London, W.14, from July 12 to 21. It will be open each day (except Sundays) from 10 a.m. to 8 p.m. Plant and equipment on show will include conveyors and elevators; coal, coke and ash-handling plants; cranes; industrial power trucks, hand lifting trucks, hoists, stackers and pulley blocks. At the convention 16 papers describing the latest mechanical-handling technique for numerous industries will be presented. Examples of current handling problems will be given and the latest methods and equipment for solving them will be dealt with. The Exhibition and Convention is being organised by our contemporary, *Mechanical Handling*, Dorset House, Stamford-street, London, S.E.1.

EXPERIMENTAL HEAT PUMP.

The British Electrical and Allied Industries Research Association have recently installed a small heat-pump plant at their Perivale Laboratory, 5, Wadsworth-road, Greenford, Middlesex, and they intend to carry out tests with it to obtain reliable data on heat-pump performance, under controlled conditions, with special reference to the use of such plant in this country. For various reasons, heat pumps have not been so extensively developed in the United Kingdom as in Switzerland and the United States, but with the present shortage and high cost of coal it is felt that they may now be more economical than coal, gas or electricity for space heating.

A general view of the plant is given in Fig. 1, opposite, from which it will be seen that there are three separate heat-pump units, i.e., three evaporators, three pumps, three compressors, three expansion valves, and three condensers, with only a few parts, such as a heat exchanger and drier, common to the three units. Such an arrangement gives a certain flexibility of control, as one or two units can be switched off as the demand falls. The plant has been taken from a German submarine, in which it was used for heating and cooling the air, and it has been re-arranged and modified to facilitate its erection and use at Perivale. The principal parts shown in Fig. 1 are the condensers on the left, and the motors, pumps, compressors and evaporators in the background

The circuit of one heat-pump unit is shown diagrammatically in Fig. 2. The working fluid is Freon 12 (dichloro-difluoro-methane, CCl_2F_2), which boils at — 21·5 deg. F., has a critical temperature of 222·7 deg. F., and is odourless, non-toxic, non-inflammable, and innocuous. It is corrosive, however, when it contains moisture, and a drier is therefore incorporated in the circuit. Commencing at the evaporator, the fluid enters, from the reducing valve, as a liquid at about atmo-

EXPERIMENTAL HEAT PUMP.

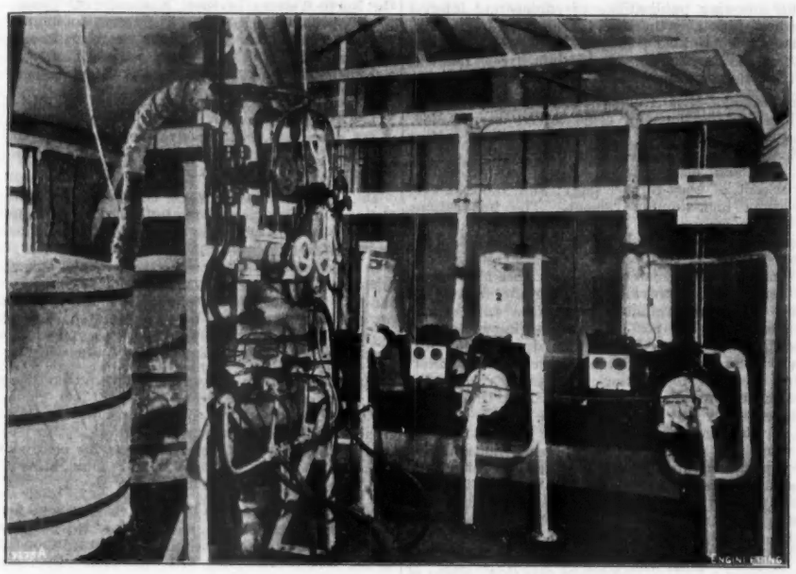
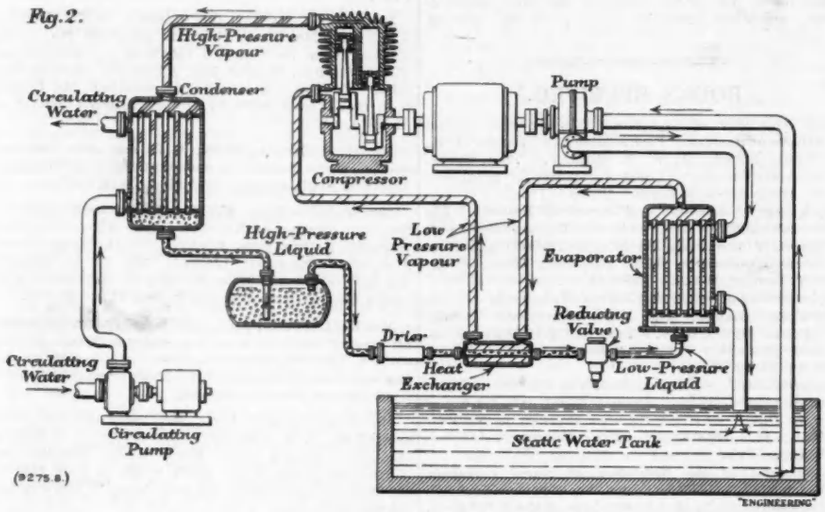


FIG. 1.

Fig. 2.



spheric pressure and slightly below its boiling point. While passing through the evaporator tubes it boils; its temperature is raised to about 30 to 50 deg. F., and it therefore leaves the condenser as a vapour, the heat having been absorbed from the source of low-grade heat—in this case a static water tank. The Freon vapour is passed through a heat exchanger, where its temperature is raised slightly, the heat being taken from the comparatively hot returning Freon. The pressure of the vapour is then increased to about 180 lb. per square inch in a single-stage compressor, and its temperature is thereby increased to approximately 130 deg. F. It should be noted that all the temperatures given here, except physical constants, are only approximate, as they vary according to the rates of flow of the vapour and water, etc.

The hot high-pressure vapour now passes into the condenser, where it gives up its latent heat of evaporation to the circulating water, and emerges as a liquid. Thence, still at a pressure of 180 lb. per square inch, it passes through a tank, which is arranged to ensure full-bore flow, the drier containing silica-gel crystals, and the heat exchanger where, as already noted, it gives up some heat to the Freon in the first part of the circuit. It is then passed through a reducing valve to lower its temperature to approximately — 22 deg. F. and its pressure to about atmospheric, after which the cycle is repeated.

There was little space available at the Perivale laboratory for installing the heat pump, so it was erected over an existing 20,000-gallon static water tank. A heat-insulated hut was built over the tank, and the equipment installed. In passing through the evaporator, the water pumped from the tank drops only about 2 deg. F. in temperature, and the rate of flow is 13 gallons per minute. A 4-kW direct-current motor drives each water pump and compressor. In practice, the motor absorbs approximately 3 kW—about 0·75 kW for the pump and 2·25 kW for the compressor, which is rated at 2·4 kW. Not all the energy absorbed by the pump is lost, some of it heating the water passing through, and, of course, most of the energy of the compressor is absorbed by the Freon. The winter has been unusually mild, and the temperature of the water in the tank has not dropped below 40 deg. F. Nevertheless, as the volume of water was comparatively small—if considered as a source of low-grade heat—it was decided to return some of the heat developed by the heat pump to avoid freezing. Accordingly, the water heated in the condenser, which normally would be used for central heating, was passed through a coiled tube in the water tank. This is only a temporary arrangement, however, as the Association hope to experiment with the tank and other sources of low-grade heat, to provide space heating.

The principal components which are common to the three heat-pump units are the heat exchanger, the drier, the liquid-Freon tank and a hand pump for priming the three water pumps. The plant could be adapted for air conditioning, in which case the direction of flow of the Freon would be reversed. When used in the German submarine, the heat or "cold" was dissipated directly from a condenser to the air which was caused to flow past it. One, two, or three heat-pump units can be used simultaneously. The plant has been operating with a coefficient of performance of about 3·5, at an output temperature of 130 deg. F. In addition to carrying out trials with alternative sources of low-grade heat, the effect of modifications to the plant will be assessed, such as water cooling instead of air cooling for the compressors, the heat absorbed by the water being usefully transferred to another part of the circuit. The research which is to be undertaken with the plant is under the direction of the committee responsible for space and water heating.

204-H.P. DIESEL LOCOMOTIVE.

A 204-H.P. 0-6-0 Diesel-mechanical locomotive has recently been constructed by the Vulcan Foundry, Limited, Newton-le-Willows, Lancashire, on behalf of the Drewry Car Company, Limited, 7, Finsbury-circus, London, E.C.2, and has been lent to the Eastern and North Eastern Regions, British Railways, who are using it in the Manchester district. The drive is through a hydraulic coupling and gearbox, and the tractive effort in low gear is estimated to be 16,850 lb.

The Gardner 8L3 engine is of the cold-starting airless injection type, and has eight cylinders each 5½ in. in diameter with a piston stroke of 7½ in. The swept volume is therefore 24·15 litres, and the engine develops 204 brake horse-power at 1,200 r.p.m. It is basically a standard Gardner engine, and is equipped with two 24-volt C.A.V. axial-pattern starter motors. Other additions are a supplementary oil pump for circulating the lubricating oil through an oil-cooler section in the main radiator, and oil-bath air filters of the A.C. Sphinx pattern. A 250-gallon fuel tank mounted behind the engine, and underneath the casing, feeds oil by gravity, and is provided with filling equipment operated by compressed air. The drive from the engine to the gearbox is through a type 23 Vulcan-Sinclair hydraulic coupling which is bolted to the flywheel. With this coupling, a gear may be engaged while the locomotive brakes are applied, without fear of stalling the engine, since the coupling transmits practically no torque at idling speed. The CA5 Wilson-Drewry epicyclic gearbox has five ratios: 4·07 to 1, 2·33 to 1, 1·55 to 1, 1 to 1, and a 1 to 1·87 overdrive. The corresponding tractive efforts and speeds, assuming the mechanical efficiency of the locomotive drive to be 75 per cent., are estimated to be: 16,850 lb. at 3·4 m.p.h.; 9,700 lb. at 5·93 m.p.h.; 6,440 lb. at 8·9 m.p.h.; 4,150 lb. at 13·8 m.p.h.; and 2,220 lb. at 25·85 m.p.h. The gearbox is operated by compressed air; an air cylinder is provided for each indirect gear, including the over-drive, and an annular air cylinder is used for engaging the direct drive. The drive from the gearbox is taken through a totally-enclosed reversing and reduction gear unit mounted on a jack-shaft; thus the five speeds may be used in both directions of travel. The reverse gears are of the spiral-bevel type, the bevel pinion being in constant mesh with two crown-wheels mounted on roller bearings and having internal teeth; a sliding clutch on a splined reverse shaft engages either of the two crown-wheels to provide forward or reverse gear. The reverse clutch is operated by compressed-air cylinders, and air for this and for the gearbox is supplied by the air-brake system through a reducing valve. The drive is finally taken from the jack-shaft to the 3 ft. 3 in diameter wheels through coupling rods.

Westinghouse air brakes and a hand-screw brake are provided. The driver's controls for engine speed, gearbox, reverse, and air brake are duplicated on each side of the cab. Pneumatic sanding is operated from a central position on each control desk. Lighting, including marker lights, is provided by a 24-volt C.A.V. system. The locomotive weighs about 30 tons in working order, and the principal dimensions are: length over frames, 22 ft. 1 in.; length over buffers, 26 ft.; maximum width, 8 ft. 7¾ in.; maximum height, 11 ft. 11 in.; and wheelbase, 9 ft.

ELECTRICAL PEAK-LOAD SUPERVISOR.—A peak load "supervisor," which has been designed to indicate and record when a pre-determined maximum demand is about to be exceeded, has been placed on the market recently by Messrs. Chamberlain and Hookham, Limited, New Bartholomew-street, Birmingham 5. This "supervisor" comprises an electricity meter from which impulses are transmitted, at a rate proportional to the load, to a contact device and thus to a step-by-step mechanism. This mechanism is provided with a pointer and scale, the latter being graduated in kilowatts or kilovolt-amperes. There is also a timing device, which disconnects the meter from the step-by-step mechanism at 5-minute intervals and restores it to its initial position. Each impulse moves the pointer towards the zero on the scale, where there is an insulated pin. If the pre-determined load is not exceeded, the pointer will not reach the zero during the 5-minute interval. If it is exceeded, however, the pointer will make contact with the pin and close a circuit to sound a hooter or light a lamp. In either case, the pointer is restored to its central position at the end of the 5-minute interval.

LAUNCHES AND TRIAL TRIPS.

S.S. "Lord Wavell."—Single-screw trawler built by Messrs. Cochrane and Sons, Limited, Ouse Shipbuilding Yard, Selby, for the Lord Line, Limited, St. Andrew's Dock, Hull. Main dimensions: 175 ft. by 30 ft. 6 in. by 16 ft. Triple-expansion engine constructed by Messrs. C. D. Holmes and Company, Limited, Alfred-street, Hull. Launch, March 25.

S.S. "Nigerian."—Single-screw vessel to carry twelve passengers, palm oil in bulk and general cargo, built by the Furness Shipbuilding Company, Limited, Haverton Hill-on-Tees, Co. Durham, to the order of The United Africa Company, Limited, Unilever House, London, E.C.4. Main dimensions: 415 ft. by 56 ft. 6 in. by 37 ft. 2 in. to shelter deck; deadweight capacity, 8,000 tons on a draught of 24 ft. North Eastern reheat triple-expansion engine, giving a speed on trial of 12½ knots, supplied by Messrs. George Clark (1938), Limited, Southwick Engine Works, Sunderland. Trial trip, April 2.

M.S. "Clytoneus."—Single-screw cargo liner, with accommodation for twelve passengers, built by The Caledon Shipbuilding and Engineering Company, Limited, Caledon Shipyard, Dundee, to the order of Messrs. Alfred Holt and Company, India Buildings, Liverpool, 2, for the Ocean Steamship Company, Limited. Main dimensions: 450 ft. by 62 ft. by 35 ft.; deadweight capacity, 9,000 tons. Eight-cylinder double-acting two-stroke B. and W. type Diesel engine, constructed by Messrs. John G. Kincaid and Company, Limited, East Hamilton-street, Greenock, developing 7,500 brake horse-power. Sea speed 16 knots. Launch, April 9.

S.S. "Rigoletto."—Single-screw cargo vessel, built at the Wear Yard of Messrs. Short Brothers, Limited, Pallion, Sunderland, to the order of the Rederi A/B Soya, Stockholm. Main dimensions: 441 ft. 6 in. by 57 ft. by 36 ft. 10 in. to shelter deck; deadweight capacity, about 9,100 tons on a draught of 25 ft. 1½ in. Triple-expansion engine of reheat design installed by Messrs. George Clark (1938), Limited, Southwick Engine Works, Sunderland, associate firm of the North Eastern Marine Engineering Company (1938), Limited, Wallsend-on-Tyne, with three multi-tubular oil-burning boilers. Service speed, 11 knots. Launch, April 9.

S.S. "A. J. Falkland."—Single-screw cargo vessel, built by Messrs. William Gray and Company, Limited, West Hartlepool, for the Rederi A/B Wallen (Axel Falkland), Helsingborg, Sweden. Main dimensions: 310 ft. by 46 ft. 10 in. by 27 ft. 10½ in. to shelter deck; deadweight capacity, about 3,500 tons on a draught of 19 ft. Triple-expansion engines, constructed by the builders' Central Marine Engine Works, with two oil-fired boilers, producing a service speed of 12 knots. Launch, April 12.

M.S. "Scarcity."—Single-screw cargo vessel built by Messrs. Goole Shipbuilding and Repairing Company, Limited, Goole, Yorkshire, for Messrs. Frederick T. Everard and Sons, Limited, Fenchurch Buildings, London, E.C.3. Main dimensions: 174 ft. by 27 ft. 6 in. by 11 ft. 6 in.; deadweight tonnage, 700. Diesel engine of 500 brake horse-power supplied by Newbury Diesel Company, Limited, Newbury, Berkshire. Launch, April 12.

M.S. "Auris."—Single-screw Diesel-electric tanker, built and engined by Messrs. R. and W. Hawthorn, Leslie and Company, Limited, Hebburn Shipbuilding Yard, Hebburn-on-Tyne, for the Anglo-Saxon Petroleum Company, Limited, Great St. Helen's, London, E.C.3. Main dimensions: 482 ft. 6 in. by 59 ft. by 34 ft. 10 in. to upper deck; deadweight capacity, about 12,000 tons. Four Hawthorn-Sulzer eight-cylinder four-cycle Diesel engines of 1,100 brake horse-power each, coupled to alternators driving one propelling motor of 3,750 shaft horse-power. One of the Diesel engines will later be replaced by a gas turbine now under construction by the British Thomson-Houston Company, Limited, Rugby, who have supplied all the electrical equipment. Trial trip, April 16 and 17.

The Institution of Naval Architects: Erratum.—We regret that two errors occurred in our report, on page 331, *ante*, of the remarks of Mr. E. C. B. Corlett in the discussion on Mr. R. J. Daniel's paper on "The Royal Navy and Nuclear Power." The reference to "radio-active condition" should read "radioactive emission"; and, six lines lower, the statement that "it seemed impossible to concentrate" should read "it seemed impossible to contemplate."

Royal Aeronautical Society.—The annual general meeting of the Royal Aeronautical Society will be held at 6 p.m., on Friday, May 7, at the offices of the Society, 4, Hamilton-place, London, W.1. The business will include the presentation of the report of Council, a financial statement, and the election of officers. The 36th Wilbur Wright Memorial Lecture of the Society will be delivered by Mr. A. Gouge, B.Sc., F.R.Ae.S., at 6 p.m., on May 27, at the Institution of Civil Engineers Great George-street, London, S.W.1. It will deal with "Size in Transport" and will be a review of the development of the subject, with particular respect to size and the application of its lessons to air transport.

BRITISH STANDARD SPECIFICATIONS.

The following publications of engineering interest have been issued by the British Standards Institution. Copies are obtainable from the Publications Department of the Institution, 28, Victoria-street, London, S.W.1, at the price quoted at the end of the paragraph.

Portland and High-Alumina Cements.—New editions of three specifications for cement have been issued. These comprise B.S. No. 12, covering Portland cement (ordinary and rapid hardening); B.S. No. 146, dealing with Portland blast-furnace cement (not exceeding 65 per cent. of blast-furnace slag); and B.S. No. 915, concerning high-alumina cement. The publications specify the composition of the various cements and sampling procedures, and the tests to determine the fineness, chemical composition, strength, setting time and soundness of the materials. The clause for fineness has been revised to provide for testing alternatively by sieving or by determining the surface area of the particles of cement per unit weight (known as the "specific surface"). The compressive-strength test only is to be used for high-alumina cement, but alternative methods for testing the strength of other cements are provided. It is pointed out that it has been necessary to re-introduce the tensile-strength test, for the time being, owing to the fact that, during the war years, some of the vibration machines needed to compact the cubes for the compression test proved to be unreliable. The causes of this trouble have been carefully investigated and a detailed specification and drawings have now been prepared, describing a reliable machine. An illustration and brief particulars of the machine are given in an appendix to each of the three specifications. Further appendices give descriptions of the methods used and the apparatus needed for the other tests. The price of each of the three specifications, which are bound in cloth, is 3*s.* 6*d.*, postage included.

BOOKS RECEIVED.

Leeds Association of Engineers. Eighty-Second Annual Report and Journal, Year Ending 31st December, 1947. Journal Editor: A. W. R. Hutley. Thos. Cooke, Honorary Secretary, Leeds Association of Engineers, 86, Alwoodley-lane, Leeds. [Price 5*s.*]

Department of Scientific and Industrial Research. The Fundamental Research Problems of Telecommunications. Reports of the Working Parties of the Telecommunications Research Committee. H.M. Stationery Office, Kingsway, London, W.C.2. [Price 1*s.* 6*d.* net.]

Department of Scientific and Industrial Research. British Regional Geology. The Welsh Borderland. Second edition. By Dr. R. W. Pocock and T. H. Whitehead. H.M. Stationery Office, Kingsway, London, W.C.2. [Price 2*s.* 6*d.* net.]

Department of Scientific and Industrial Research. Report of the Water Pollution Research Board, with the Report of the Director of Water Pollution Research, for the Year 1946. H.M. Stationery Office, Kingsway, London, W.C.2. [Price 1*s.* net.]

Transactions of the Institution of Naval Architects. Volume 89. 1947. Edited by Captain (S) A. D. Duckworth, R.N. (Ret.), Secretary of the Institution. Offices of the Institution, 10, Upper Belgrave-street, London, S.W.1; and Henry Sotheran Limited, 2, Sackville-street, London, W.1. [Price 5*l.* 5*s.* net.]

Twenty-Second Report of the Electricity Commissioners. 1st April, 1946, *to 31st March*, 1947. H.M. Stationery Office, Kingsway, London, W.C.2. [Price 2*s.* 6*d.* net.]

British Standards Institution. Yearbook, 1947. Offices of the Institution, 24-28, Victoria-street, London, S.W.1. [Price 3*s.* 6*d.*, post free.]

Crosville: The Sowing and the Harvest. By W. J. Crosland-Taylor. Littlebury Brothers, Limited, 3, Crosshall-street, Liverpool. [Price 7*s.* 6*d.*]

Ministry of Labour and National Service. Factory Department. Safety Pamphlet No. 17. *Accident Prevention in Brick, Pipe and Tile Manufacture.* H.M. Stationery Office, Kingsway, London, W.C.2. [Price 2*s.* net.]

Department of Scientific and Industrial Research. Memoirs of the Geological Survey of Great Britain. Dudley and Bridgnorth. By T. H. Whitehead and R. W. Pocock. H.M. Stationery Office, Kingsway, London, W.C.2. [Price 7*s.* 6*d.* net.]

Involute Gears. By W. Steeds. Longmans, Green and Company, Limited, 6 and 7, Clifford-street, London, W.1. [Price 18*s.* net.]

United States National Bureau of Standards. Circular No. C461. *Selected Values of Properties of Hydrocarbons.* Superintendent of Documents, U.S. Government Printing Office, Washington 25, D.C., U.S.A. [Price 2.75 dols.]

Modern Workshop Technology. Part I. *Materials and Processes.* Edited by Professor H. Wright Baker. Cleaver-Hume Press, Limited, 42a, South Audley-street, London, W.1. [Price 28*s.* net.]

PERSONAL.

Mr. E. H. Browne, at present production director of the North-Western Division, National Coal Board, has been appointed Chief Mining Engineer (Planning) to the Board. The present Chief Mining Engineer, Professor Douglas Hay, M.C., B.Sc. (Eng.) (Lond.), M.I.C.E., is to continue as Chief Mining Engineer (Management).

Colonel F. Hibbert, C.B.E., M.C., M.I.C.E., M.I.W.E., chief engineer, Liverpool Corporation Waterworks since 1934, is to receive the honorary degree of M.Eng. of the University of Liverpool at a degree-day ceremony to be held on July 3.

Dr. A. D. Merriman, G.C., O.B.E., M.A. (Cantab.), M.Ed. (Dunelm), took up the full-time post of registrar-secretary of the Institution of Metallurgists on April 20. Dr. Harold Moore, C.B.E., the Institution's first President, has served as registrar hitherto. The agreement under which Mr. K. Headlam-Morley, secretary of the Iron and Steel Institute, has acted also as secretary of the Institution has been terminated, but office accommodation will continue to be provided for the Institution at 4, Grosvenor-gardens, London, S.W.1.

Mr. H. A. Lingard, director of lamps and lighting sales and a member of the board of the British Thomson-Houston Company, Limited, is shortly retiring owing to ill-health. He will continue to act in an advisory capacity and, as stated on page 322, *ante*, his place on the board will be taken by Mr. V. C. H. Creer, M.A. (Cantab.), whose appointment dates from May 1.

Mr. Robert Askin has been appointed general manager of Meldrums Limited, a company of the Brockhouse Organisation, in succession to Mr. Arthur Wood. Mr. Askin, who was formerly with Brockhouse Engineering (Southport) Limited, takes up his new appointment on May 1.

Mr. F. G. Bacon, B.Sc. (Eng.), A.M.I.Mech.E., A.M.I.E.E., Mr. H. C. Blench, M.C., and Mr. J. M. Graham have been elected directors of International Alloys, Limited, Haydon Hill, Aylesbury, Buckinghamshire. Mr. Bacon is director of production, Mr. Blench is director of sales, while Mr. Graham is also a director of Almin, Limited.

Mr. O. I. Butler, M.Sc., A.M.I.E.E., has been appointed senior lecturer in charge of the Department of Electrical Engineering of the University of Sheffield.

Mr. W. H. Bowman, M.I.Mech.E., has been appointed technical director of Reynolds Light Alloys Limited, Reynolds Rolling Mills Limited, and the South Wales Aluminium Company, Limited. Mr. E. G. Snelus has been appointed sales manager of Reynolds Light Alloys Limited, and Reynolds Rolling Mills Limited.

Mr. R. H. Young, B.Sc., A.M.I.E.E., has relinquished his position as assistant sales manager to Woods of Colchester, Limited, Colchester, Essex, which position he has held since 1935, except for a break from 1940 to 1946 when serving with H.M. Forces.

Mr. W. H. Salmon, Assoc. Met. (Sheff.), F.I.M., is to succeed Mr. J. H. Whittam as representative of Messrs. Hadfields Limited, East Hecla Works, Sheffield, in North-West England and North Wales, as from May 1. Mr. Whittam has acted as the firm's agent in this area for the past nine years.

Mr. W. C. Collins, A.M.Inst.T., formerly indoor assistant to traffic manager, Southern Region, British Railways, has been appointed senior secretarial assistant (traffic section), British Transport Commission, 55, Broadway, Westminster, London, S.W.1. Mr. R. B. Lewis, formerly private secretary to the chief regional officer, Western Region, is to be senior secretarial assistant (development and works section), British Transport Commission.

The Fire Offices Committee Fire Protection Association have removed to 84, Queen-street, London, E.C.4. (Telephone: CENtral 4642.)

Messrs. J. H. Fenner and Company, Limited, have opened a new branch office at 86, Bridge-street, Sheffield, 1 (Telephone: Sheffield 27774). The manager is Mr. G. K. Varley.

"Electricity in Spinning."—A booklet issued this week by the North-West England and North Wales Area Committee of the British Electrical Development Association, 1, Dickinson-street West, Manchester, 2, describes the use of electricity in the spinning industry and gives much useful information on the selection of motors for this purpose. The planning of conversions to the electric drive, the desirability of regular checks on consumption and the benefits of standardisation as a means to greater economy are also dealt with. It is recorded that over 85 per cent. of the cotton-spinning mills in this country take a supply of electricity from the public mains for one purpose or another. About 35 per cent. of the ring spindles are electrically driven.

NOTES FROM THE NORTH.

GLASGOW, Wednesday.

Scottish Steel.—Steel production is still somewhat below the maximum capacity of the local industry, owing to an inadequate supply of scrap. One or two idle furnaces are ready to be utilised, but the absence of a reasonable guarantee of regular supplies of scrap prevents their going into production. Satisfactory progress continues to be made with the collection of scrap from home sources, but these must be supplemented by imports. Arrivals at Scottish ports this year from Germany have not been up to expectations, but have helped to increase the number of furnaces in operation. Outputs from the rolling mills have been at a high level, and re-rollers have been receiving good tonnages of billets. Adequate supplies of slabs have been sufficient to keep the heavy mills in the sheetmaking branch working at full capacity, but the lighter mills have been handicapped by the continued shortage of sheet bars. Tubemaking is one of the busiest sections of the industry, and books are well filled with orders, notably in connection with developments in the oil industry overseas. The works are operating at maximum capacity, and the consumption of tube strips, bars, and ingots, is heavy. Export allocations for Period 2 have now been made, and include a substantial tonnage of sponsored orders for preferential markets.

Scottish Coal.—Deep-mine production in the Division, during the week ended April 10, was 469,300 tons, which was only 1,100 tons higher than in the previous week when outputs were affected by the Easter Holidays. In Lanarkshire recently, several hundred tons have been lost daily as a result of unofficial stoppages, but while Fife, Ayrshire, and the Lothians have remained free from major labour troubles production has remained low owing to the lack of improvement in output per man-shift. This has been most marked in Fife, where production has declined from an average of 141,000 tons a week, early in the year, to 136,000 tons. Supplies to some classes of consumers have had to be reduced below the programme rate of delivery, but owing to the consolidation of stocks effected previously, the average receipts to date, among all users, have been practically equal to the winter allocation. Increasing air temperatures have reduced domestic consumption, and the recent available tonnages of round coal have been adequate for the requirements of both the railways and the domestic market. Anthracite supplies are showing signs of improvement, particularly in the extreme sizes.

NOTES FROM THE SOUTH-WEST.

CARDIFF, Wednesday.

Welsh Coal Trade.—Operations on the Welsh steam-coal market during the past week have been on a much busier scale in so far as the export trade is concerned. This section has been on reduced lines since the Easter Holidays, owing to the loss of production and the overriding requirements of the home section. Outputs have now returned to normal, very largely, and after the arrears of deliveries to the principal inland consumers had been made good, there has been more coal to spare for export. During the week, there was a burst of activity in respect of Portugal and Argentina. In connection with the latter, an interesting development has been the conclusion of two contracts, one in respect of Spanish ships at 25*s.* a ton and the other for British vessels at 27*s.* a ton, to lift coals over the rest of the year. Altogether, each contract will be in respect of about 20 voyages and between them they will account for some 320,000 tons this year. There seem excellent prospects of an early increase in the present weekly allowance of 3,000 tons of Welsh coals for France, while another cargo of about 3,800 tons was arranged for West Italy. The principal home consumers are still making heavy calls on outputs and very little of the better qualities is available for delivery for several months. There has been little seasonal falling off in the demand so far, although when this takes place shippers are expecting to have larger quantities to offer foreign users. The demand for bunkers has been steadily maintained, while that for patent fuel and cokes was in excess of available supplies for early delivery.

Swansea Steel-Sheet Industry.—The market report issued by the Incorporated Swansea Exchange states that, last week, the demand for tin-plates was well maintained. As, however, makers are already heavily committed for the prevailing second quarter of the present year, the volume of business transacted has been on a reduced scale. The export market is rather quiet, as makers have only limited quantities for sale. Steel sheets and also iron and steel scrap are in great demand.

OVERSEAS STANDARD SPECIFICATIONS.—Our attention has been drawn to the benefits which manufacturers of plant, equipment and products for export can obtain by consulting the library of overseas standard specifications maintained by the British Standards Institution. Merchants and exporters desiring information should apply to the director of the Institution, 28, Victoria-street, London, S.W.1.

NOTES FROM SOUTH YORKSHIRE.

Iron and Steel.—The production of steel increases steadily, but users are not able to satisfy their requirements, particularly users of high-carbon steels. Speaking in the district, Sir John Duncanson, British Iron and Steel Federation director, who was war-time steel controller, said he did not believe there was a shortage of steel in Britain. He agreed there were serious bottlenecks in the industry, but attributed supply difficulties to the Government's priority scheme. Final tests are being made at Sheffield of a hydraulic press for converting powdered tin, copper and graphite into engineering components. It has been designed and built by Messrs. Davy and United Engineering Co., Ltd., Sheffield. The press is specially suitable for manufacturing large numbers of standard components, the shape and size of which can be altered by changing the tools.

South Yorkshire Coal Trade.—A recurrence of disputes among shot-firers has reduced coal outputs seriously. The demand is strong, and there have been further allocations of best coal for export. Industrial steams are in keen request; stocks at works are much higher than a year ago. More coking coal is needed to permit the operation of coke-ovens at the full heats necessary to meet the heavy demands for hard coke. Outcrop coal production is increasing, and larger proportions of outcrop coal are being directed to the steam-coal and domestic markets.

NOTES FROM CLEVELAND AND THE NORTHERN COUNTIES.

MIDDLESBROUGH, Wednesday.

General Situation.—Iron and steel producing plants continue to turn out very heavy tonnages, but both home and overseas customers are still calling for maximum deliveries against running contracts. Export quotas for the second quarter of the year are on a substantial scale and the hope is expressed that they will be executed without a diminution of the clearances of material for home purposes. The output of the Cleveland ironstone mines has been increased considerably and imports of foreign ores continue on a satisfactory scale. Some expansion in the supply of cast-iron scrap from home sources is reported, but much larger parcels are urgently needed. Pig iron is still wanted in larger quantities than producers can provide.

Foundry and Basic Iron.—Foundry owners have kept their plant much more actively engaged than might have been expected, but to do so they have depleted their stocks of pig iron and are now greatly in need of larger allocations. Midland furnaces are the main source of supply of foundry pig, but little tonnage of that commodity is obtainable elsewhere. Under such conditions, North East Coast foundry iron consumers cannot rely on regular adequate deliveries. Basic-iron production is on an improved scale and parcels reaching makers' own consuming plants are about sufficient for essential requirements; steel scrap also is a trifle less scarce than of late.

Hematite, Low-Phosphorus and Refined Iron.—Makers of East Coast hematite are managing to maintain deliveries to regular users, and manufacturers of low-phosphorus grades of iron also are able to cover consumers' requirements. Producers of refined qualities of iron report ready buyers for their products.

Manufactured Iron and Steel.—Semi-finished iron is in sufficient demand to keep makers busily employed and the production of various descriptions of finished iron is steadily taken up; the demand for larger deliveries of steel continues. Ingot production is exceptionally heavy and is now permitting great activity at the rolling plants; supplies of billets and sheet bars from home sources to the re-rolling mills are improving. The demand for finished commodities is still intense. Makers hold large export quotas and hope to deal satisfactorily with their overseas commitments. Shipbuilders are receiving good parcels and engineers with extensive overseas contracts are getting special consideration.

Scrap.—Iron and steel scrap is still wanted in much larger quantities than are coming forward, though the appeal for larger parcels has given an impetus to the scrapping of redundant and obsolete plant resulting in some acceleration in the tonnage deliveries to the steel-works.

THE ECONOMICS OF DISTRICT HEATING: ERRATUM.—Our attention has been drawn to an error which appears in our article on "The Economics of District Heating", on page 373, *ante*. Mr. A. Stubbs, the author of the paper discussed, informs us that the "annual cost for space heating and hot water per householder", which was given as 11*l.* 14*s.* per annum in the copies of the paper distributed before the meeting of the Institution of Mechanical Engineers on April 9, should have read 11*l.* 1*s.* 4*d.*

NOTICES OF MEETINGS.

It is requested that particulars for insertion in this column shall reach the Editor not later than Tuesday morning in the week preceding the date of the meeting.

INSTITUTION OF ELECTRICAL ENGINEERS.—Monday, April 26, 5.30 p.m., Savoy-place, Victoria-embankment, W.C.2. Discussion on "Industrial Applications of Photo-Electric Cells," opened by Mr. F. Baxendale. *Scottish Centre:* Tuesday, April 27, 6.15 p.m., Royal Technical College, George-street, Glasgow. Annual Meeting. Informal Discussion on "The Nationalisation of the Electricity Supply Industry," by Mr. J. S. Pickles. *Institution:* Thursday, April 29, 5.30 p.m., Savoy-place, Victoria-embankment, W.C.2. "The Economical Utilisation of Electricity in Great Britain," by Mr. R. B. Giles.

INSTITUTION OF THE RUBBER INDUSTRY.—*Midland Section:* Monday, April 26, 7.15 p.m., James Watt Memorial Institute, Birmingham. Annual Meeting and Chairman's Address.

JUNIOR INSTITUTION OF ENGINEERS.—*Sheffield Section:* Monday, April 26, 7.30 p.m., 198, West-street, Sheffield. "Some Aspects of Automobile Design," by Mr. D. H. Millar. *Institution:* Friday, April 30, 6.30 p.m., 39, Victoria-street, Westminster, S.W.1. "The Hallade Track Recorder," by Mr. W. M. Bond. *North-Western Section:* Friday, April 30, 7 p.m., 16, St. Mary's Parsonage, Manchester. Presidential Address, "The Coronation Scot: A Railway Development." by Mr. R. A. Riddles.

INSTITUTION OF CIVIL ENGINEERS.—Tuesday, April 27, 5.30 p.m., Great George-street, S.W.1. James Forrest Lecture on "Relaxation Methods of Stress Analysis," by Professor Sir Richard Southwell. *Newcastle-on-Tyne Association:* Tuesday, April 27, 6.15 p.m., Neville Hall, Westgate-road, Newcastle-upon-Tyne. (i) "Manufacture of Reinforced-Concrete Piling," by Mr. R. D. Mackey. (ii) "Pile Driving," by Mr. T. D. Miller.

INSTITUTE OF REFRIGERATION.—Tuesday, April 27, 5.30 p.m., Institution of Mechanical Engineers, Storey's gate, St. James's Park, S.W.1. (i) "Compressor Valve Design," by Mr. R. L. Quertier. (ii) "Valves for Refrigeration Compression Machinery," by Mr. E. G. Rowledge.

SOCIETY OF INSTRUMENT TECHNOLOGY.—Tuesday, April 27, 7 p.m., Manson House, Portland-place, W.1. "Some Impressions of Modern American Instrumentation," by Mr. A. J. Young.

INSTITUTE OF BRITISH FOUNDRYMEN.—*Birmingham Branch:* Wednesday, April 28, 7.15 p.m., James Watt Memorial Institute, Birmingham. Annual Meeting. *London Branch:* Wednesday, April 28, 7.30 p.m., Waldorf Hotel, Aldwych, W.C.2. Annual Meeting. "Foundries in the United States," by Mr. F. E. Tibbenham.

INSTITUTION OF PRODUCTION ENGINEERS.—*Luton Graduate Section:* Wednesday, April 28, 7.30 p.m., Technical College, Luton. Annual Meeting. *Halifax Graduate Section:* Saturday, May 1, 2.30 p.m., White Swan Hotel, Halifax. Luncheon, followed by the Annual Meeting. Lecture and film on "The Manufacture of Gas Turbines," by Mr. L. H. Leedham.

INSTITUTE OF METALS.—Thursday, April 29, 4, Grosvenor-gardens, S.W.1. 3.45 p.m., Film on "The Methods of Research Used by the Jungfraujoch Glaciological Research Party in 1938." 5 p.m., Discussion on "The Flow of Ice and Other Solids," opened by Dr. E. Orowan, F.R.S., and Dr. M. F. Perutz.

ROYAL STATISTICAL SOCIETY.—*Industrial Applications Section:* Thursday, April 29, 6.30 p.m., The Royal Victoria Hotel, Sheffield. "Statistical Methods Applied to the Inspection and Testing of Aeronautical Materials," by Mr. R. A. Nowlan.

INSTITUTION OF MECHANICAL ENGINEERS.—*North-Western Administration and Production Group:* Thursday, April 29, 6.45 p.m., Engineers' Club, Manchester. Discussion on "Production Problems in the General Engineering Workshop," opened by Mr. J. M. Newton. *Institution:* Friday, April 30, 5.30 p.m., Storey's-gate, St. James's Park, S.W.1. Gaumont-British Instructional Film on "Atomic Physics." AUTOMOBILE DIVISION. *Birmingham Centre:* Tuesday, April 27, 7 p.m., James Watt Memorial Institute, Birmingham. Annual Meeting. "Recent Developments in Automobile Transmissions," by Professor Ewen M'Ewen. *North-Western Centre:* Wednesday, April 28, 7.15 p.m., Engineers' Club, Manchester. Annual Meeting. "Test Methods and Some Instruments," by Mr. E. B. Stead.

ROYAL INSTITUTION.—Friday, April 30, 9 p.m., 21, Albemarle-street, W.1. "The Age of the Universe," by Professor Sir Harold Spencer Jones.

MANCHESTER STATISTICAL SOCIETY.—*Industrial Group:* Friday, April 30, 6.45 p.m., 16, St. Mary's Parsonage, Manchester. "The Mathematics Division of the National Physical Laboratory," by Mr. E. C. Fieller.

THE MANUFACTURE OF FLUORESCENT ELECTRIC LAMPS.

THE GENERAL ELECTRIC COMPANY, LIMITED, LONDON.

(*For Description, see Page* 391.)

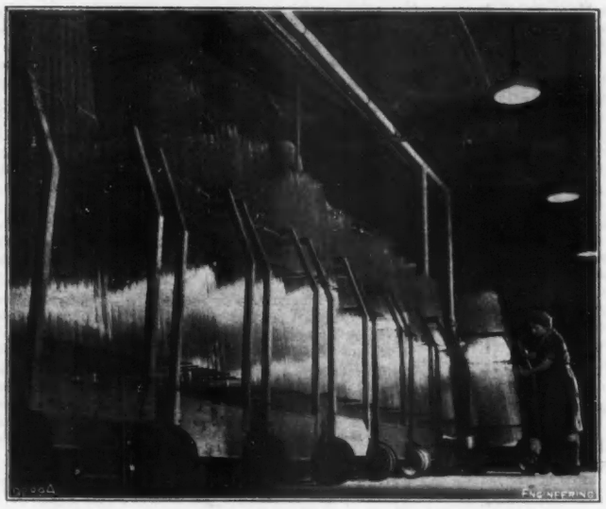


Fig. 1. Stocks of Glass Tubing for Fluorescent Lamps.

Fig. 2. Applying the Fluorescent Coating.

Fig. 3. Removing the Coating from Ends of Tubes.

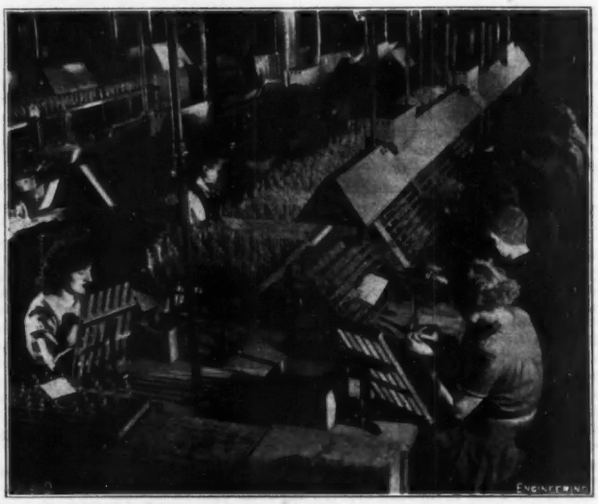


Fig. 4. Assembling the Electrodes.

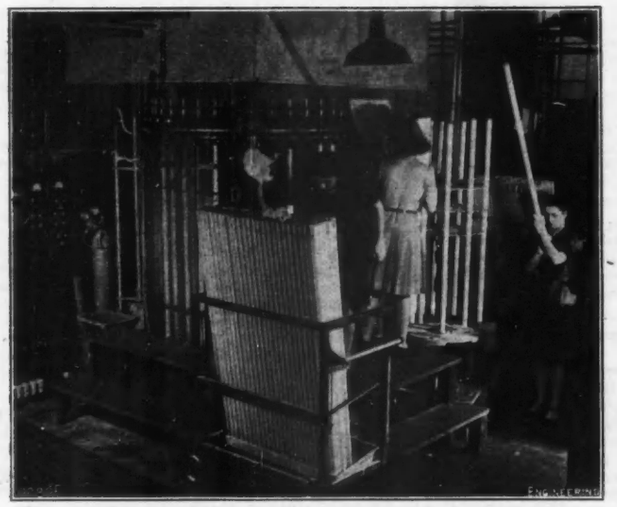


Fig. 5. Exhausting, Dosing and Sealing the Tubes.

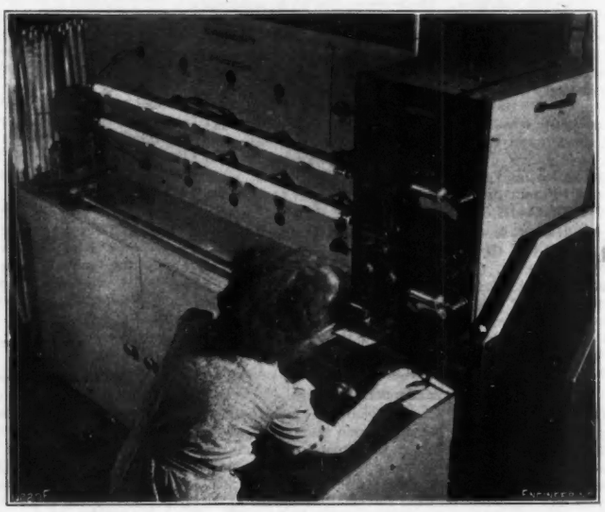


Fig. 6. Testing the Finished Lamps.

ENGINEERING.

35 & 36, BEDFORD STREET, STRAND, LONDON, W.C.2.

We desire to call the attention of our readers to the fact that the above is the address of our Registered Offices, and that no connection exists between this Journal and any other publication bearing a similar title.

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Classified advertisements intended for insertion in the current week's issue must be received not later than first post Wednesday.

"Copy" instructions and alterations to standing advertisements for display announcements must be received at least 10 days previous to the date of publication, otherwise it may be impossible to submit proofs for approval.

The Proprietors will not hold themselves responsible for advertisers' blocks left in their possession for more than two years.

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ENGINEERING

FRIDAY, APRIL 23, 1948.

VOL. 165. No. 4291.

PRINCIPLES AND PRECEDENTS.

ON another page of this issue we print a letter from a correspondent whose forthright expressions of opinion are not unknown to readers of ENGINEERING. Our reasons for doing so, however, are not so much that the views put forward in this letter are typical of a considerable number that have reached us during the past ten days or so, but that many of the corporate members of the Institution of Mechanical Engineers appear still to be unaware of the full implications of the proposals which were formally put to a special meeting in London on April 8 and are now in process of submission to a postal poll. As is now generally known, these proposals are that certain increases shall be made in the subscription rates and the corresponding fees for life membership. That some increase must be accepted eventually, whatever the result of this poll, is a conclusion hardly to be avoided, though many members hold, with some reason, that the case for an immediate advance has not yet been established and that it should be possible to run an institution, even of the size of the Mechanicals, on an income which was little short of 74,000*l.* in 1947 and may be expected to approach 80,000*l.* in 1948. What is much more important, in our opinion, is the manner in which the relevant by-laws of the Institution have been interpreted by the Council to the disadvantage of the members, and the dangerous precedents that will be created if these interpretations and the present proposed alterations are allowed to pass.

When, in 1920, the previous increases in subscriptions were made, the general background of post-war conditions and rising costs was broadly similar to the present situation, but in other ways the circumstances were considerably different. A revenue surplus in 1918 had been followed in 1919 by a deficit of 2,159*l.*—a matter of 9·6 per cent. of the total revenue in that year and about 6*s.* 4*d.* per head of the total membership. In 1920, the deficit had doubled at 4,350*l.*, or 11*s.* 7*d.* per head, and the case for an increase was evident. The new draft by-laws were circulated with the monthly journal on January 14, 1920; various members submitted amendments; and, on January 23, at the ordinary monthly general meeting, notice of motion was given, covering the Council's proposals and the members' amendments. These were discussed at the annual general meeting—an open meeting—on February 18, and the discussion was concluded, and the new by-laws adopted, on March 5, 1920.

By contrast, the procedure in 1948 appears the reverse of attractive. At the annual general meeting on March 19 of this year, apart from some general observations on rising costs, especially of printing, nothing was said to indicate that notices calling a special general meeting to consider increased subscriptions were already printed. They bore the date March 18—a Thursday—but were not posted until Saturday, March 20, so that the members did not receive them until March 22. They set out two separate resolutions, relating to the separate by-laws governing subscriptions and compounding fees, respectively, and announced that, following the special meeting, a postal poll would be taken. It may be noted that the accounts for 1947 showed a deficit of 1,560*l.*—2·1 per cent. of the revenue and a mere 1*s.* 1*d.* per head of the total membership. As against this deficit of 13 pence per head, the realisable assets amounted to more than 13*l.* per head; and, incidentally, three additional reserve funds had been established in the preceding five years, one of which—the Deferred Publications Reserve—contained more than 12,000*l.* The General Reserve Fund contained nearly 74,000*l.*, approximately the cost of maintaining the Institution for a year.

The by-law governing the voting at general meetings states that "the decision of a general meeting shall be ascertained by show of hands . . . or by a poll . . . if after the show of hands a poll is forthwith demanded by the Chairman or by at least seven of the corporate members present." It does not expressly forbid a previous announcement of the intention to take a poll, probably because such a possibility had not been foreseen, but the previous announcement in this case, as might be expected, kept many members away from a meeting which, virtually, they had been told would not be conclusive. The fact that the meeting was not held on a Friday, the customary meeting night, and was not mentioned in the pocket programme on which many members rely as a reminder, undoubtedly helped to reduce the attendance.

In general, the meeting pursued a normal course until, after about 1½ hours, the chairman unexpectedly announced that he would put the resolutions, and did so in spite of protests from members who still wished to speak. The two resolutions were put as one; the votes by show of hands were not counted or the result announced; and, after the formal statement that a poll would be taken, the meeting was declared closed. Subsequent inquiry disclosed that no report of the meeting was to be sent out to the members to whom the voting papers were even then ready to be distributed. The papers, dated April 9, and purporting to convey the result of the meeting, were in the post next day, and proved, incidentally, to bear only one resolution, combining the two on the original notice, and only one space on which to record a single vote, for or against.

This adroit manipulation of the by-laws contains in itself sufficient reason for dissatisfaction on the part of the members and certainly never could have been envisaged by those who compiled these regulations some 17 years ago; but the real concern that it causes lies in the undesirable precedents created. The earlier precedent of an elaborate secrecy, which characterised the proceedings leading to the amalgamation with the Institution of Automobile Engineers, was exploited to the full. The notice convening the special meeting, and the voting paper (required to be signed by the voter—another precedent which should have been rejected firmly on its introduction at the time of the amalgamation) were quite unnecessarily marked "Private and

Confidential"; though it would appear that even the Council did not expect this to be taken seriously as the notice was sent out unsealed and unenclosed as a folded circular which might have been opened by any inquisitive person and, in fact, had to be opened before the "Private and Confidential" inscription could be seen. The voting paper is returnable similarly unsealed through the post, with only a penny stamp, and no indication that it is "confidential" appears when it is folded for posting. It seems, indeed, as though the main purpose of the inscription is to inhibit the free comment which, in 1920, was considered normal and proper.

The device of putting the two resolutions as one, however plausible at a cursory glance, is thoroughly undesirable as a principle. If two resolutions, relating to separate by-laws which do not necessarily stand or fall together, can be thus lumped together, why not twenty-two? On the face of it, once the precedent is established and the sanction of a general meeting has been obtained by some means there is nothing to prevent an entirely new set of by-laws from being similarly thrust upon the members; there is no by-law which enforces separate consideration and a separate vote upon each or any of them. It is the readiness of the Council to take advantage of such loopholes which is the prime cause that the dissatisfaction engendered by the events of two years ago tends to increase rather than to diminish as being inadequate. The report of the amalgamation meeting in London two years ago, as then circulated to the members with their voting papers, was widely criticised. This time, there is no report at all. If the process continues, the members may find one day that there has been not only no report but no meeting; a possibility clearly foreseen in an article published last week in *The Engineer*.

We have no hesitation whatever in urging the need to oppose such a proposal by all practicable means if ever it should be put forward seriously by any engineering institution; certainly, if it is unaccompanied by provision for the expression by members of their individual views, or opportunity to communicate them to the rest of the voters. The fact that some recent special meetings have been sparsely attended is not a reason for abolishing special meetings, but for taking steps to make them more effectively representative. If the meetings are advertised to be a mere matter of form, naturally they are liable to be treated as such, and a previous announcement that a poll will be taken must have just that effect; but these meetings, in the Institution of Mechanical Engineers, were never intended to be a mere matter of form. They were intended to be executive and decisive, the poll being a supplementary means of arbitrament in cases of doubt. The process whereby the status of special meetings has become undermined is more than a little reminiscent of the technique that has been applied so often and so successfully all over Europe in recent years, and in certain industrial spheres at home: first, create conditions in which the existing machinery cannot function, and then demand that it be scrapped as ineffective—to be replaced by something of a much less flexible type.

Such methods, to say the least, are inappropriate to professional institutions. The point at issue is not one of legality, but of ethics; but in ethics there are several standards. There is one standard of the professions, another standard of commerce, and another standard of politics; and one standard differeth from another standard in rigidity. In the matter which gave rise to this commentary, many members of the Institution of Mechanical Engineers may feel that the lines of demarcation have become somewhat indistinct. They were plainly told by their President, not long ago, that they have the remedy in their own hands: but some of them need to be reminded also that it is not only nations which get the Governments they deserve. The professional engineering institutions are not yet ruled by presidential decree and we hope devoutly that they never will be; but, in the light of recent tendencies, such a notion is not nearly so fantastic as it would have appeared even ten years ago. In our opinion, the abolition of special general meetings, or any added restriction upon the right of members to call for them, would bring it appreciably nearer to fulfilment.

AMERICAN SYNTHETIC LIQUID FUEL PRODUCTION.

The dominant position which the internal-combustion engine has taken in the various activities of the world is one of the major phenomena of modern engineering development. For road and air transport, it has no rival of any importance, and there are signs that it may ultimately win an equally commanding position for railway service. Tentative beginnings may be seen in Great Britain, and in the United States more than 90 per cent. of railway locomotives now on order are of the Diesel-engine type. At sea, the motorship has long since proved to be more than a formidable rival of the steamer. It would appear that a position is being approached in which use of steam plant will be mainly restricted to industrial processes and large-scale power production on land. Oil-fuel firing is not unknown even for electric-generating stations, but some recent conversions from coal to oil undertaken in this country were dictated rather by something in the nature of panic than by judgment, and broad considerations suggest that in Great Britain, which has no native oil supplies, coal will remain the fuel for thermal power stations. Even with this exception, however, the demand for liquid fuel for other services will continue to be of major economic importance.

The United States is vitally interested in this question of liquid fuels. Demand is increasing and home supplies are diminishing. The total demand for this year is estimated as 14·2 per cent. higher than the war-time peak in 1945, and the total consumption is 63 per cent. of that of the world. Although the United States is a great oil producer, it is now estimated that it contains only 31 per cent. of the world's reserves. The proved reserves of crude oil are estimated at 21,000 million barrels, and the corresponding figure for the Middle East is 27,000 million, but exploratory drilling suggests that this latter figure will be raised to 50,000 million. From the point of view of world economics, it is an advantage that the United States should find it necessary to import a substantial proportion of its liquid fuel, but those responsible for conducting its affairs must consider the possibilities of the future. The oil consumption of the rest of the world increased by 13 per cent. in 1946, as compared with 1941, and the consumption during 1947 was still higher. This tendency, in time, may restrict the quantity available for purchase. There is a further consideration of importance; liquid fuel is a vital war material and in an uneasy world the difficulty of transporting large quantities of oil from the Persian Gulf, or even from South America, in the face of enemy action, is a matter of grave concern. The possibility of foreign supply sources being destroyed in war has also to be borne in mind.

In view of these various considerations, the United States Congress in 1944 passed the Synthetic Liquid Fuels Act, which provided for the expenditure of 30 million dollars, over five years, on synthetic liquid-fuel research. The work was placed in the hands of the Bureau of Mines and the purpose was an extensive investigation of the whole field from the point of view of the possibility of establishing a synthetic liquid fuel industry which, employing native raw materials, would constitute an alternative source of liquid fuel supplies. Much work has been done by the Bureau since 1944, but it cannot be supposed that it has come to the end of the problems with which is was faced. As the authorisation under the Act comes to an end next year, a Bill has been presented to Congress for the continuation and great extension of the investigations. It proposes the allocation of 400 million dollars, a substantial proportion of which would be spent on the construction of large-scale plants. The Bill authorises the Reconstruction Finance Corporation to make loans to private industry for the construction of plants, but if 120 days after the passing of an Act no commercial organisation accepts this offer of assistance, the Corporation may itself proceed to the construction of plants.

In applying the original Act, the Bureau of Mines has investigated three methods of synthetic oil production. None of these is novel, but they represent new developments in United States practice. The three methods are the treatment of oil shale in retorts, the production of liquid fuels by the hydrogenation of coal, and the manufacture of petrol and Diesel-engine fuel by the Fischer-Tropsch process. The time which has been available since the work was started has been spent, to a considerable extent, in preliminary investigations, design and experiment, and only in the case of shale oil is a semi-commercial plant yet in operation. A demonstration hydrogenation plant for an output of 200 barrels of petrol a day is under construction and is expected to be in operation this year. The Fischer-Tropsch work is not so far advanced, and work on a 50-barrel a day unit, which has been designed, has only just been put in hand. Before building up a large-scale industry, it is necessary that practical experience should be obtained with demonstration plants of this type, but the new Bill contemplates something much more ambitious and proposes plants of 10,000 barrels a day capacity.

There is no question but that the United States can, if desired, build up a large-scale synthetic oil industry. That was proved by Germany during the war, when a production of 3,250,000 metric tons a year of hydrogenation spirit was attained. The cost per gallon, however, was twice that of imported spirit. If the United States government considers that security and an unfailing supply of liquid fuels to its transport services and industries are worth the cost, then a subsidised industry can be created. Even in a wealthy country, however, some regard must be paid to economic considerations, and if a world liquid-fuel shortage results in a serious increase in cost, one way to meet the situation is to use less.

It is estimated that the establishment of a synthetic-fuel industry with a capacity of two million barrels of oil a day, less than 40 per cent. of current consumption, would cost 9,000 million dols. and require 16 million tons of steel. This represents an undertaking of ten times the magnitude of the synthetic-rubber programme which was carried out during the war. It would take many years to complete and if, as a matter of broad policy, it is decided that such an industry should be created, it is clearly necessary that a start should be made. In the field of hydrogenation, the Bureau of Mines has laid a promising foundation. In working out the design for the demonstration plant which is being erected, study of German plants has been conducted and modifications and improvements devised which it is expected will increase the efficiency, as measured by the heat in the coal compared with the heat in the oil produced, from 30 per cent. to 50 per cent. The plant will operate at pressures from 4,000 lb. to 10,000 lb. per square inch, which is approximately the same as the range which was covered by German practice. It is estimated that aviation petrol can be produced at a cost of about 14 cents a gallon.

Of the three fields of investigation in which the Bureau of Mines has been engaged, the production of liquid fuel from oil shale shows the greatest progress and a demonstration plant is in full operation. Although the distillation of oil from shale is a simpler problem than that presented either by hydrogenation or Fischer-Tropsch conversion, these latter processes have been able to utilise raw material in general supply, while for the oil-shale work it has been necessary to develop methods for the winning of the shale. Much of the time available has been spent on this work, but two mines have been opened up in Colorado, the larger of which has a capacity of 1,500 tons a day, although this output has not yet been reached. Extensive drilling equipment, transporters and other types of plant have been installed. The shale available has an average content of 30 gallons of oil per ton. The crude oil produced has been used in engine tests, for boiler fuel and in distillation experiments, but for the production of light Diesel oils and motor spirit on an important scale it would be necessary for the present refining plant to be developed and extended. The Fischer-Tropsch plant now under construction will have a capacity of 50 to 80 barrels a day, but its layout will permit enlargement to 500 barrels a day.

NOTES.

INSTITUTION OF MECHANICAL ENGINEERS.

BEFORE Dr. H. I. Andrews, M.Sc. (Eng.), A.M.I.Mech.E., presented his paper on "The Mobile Locomotive Testing Plant of the London Midland and Scottish Railway," at the meeting of the Institution of Mechanical Engineers which was held on Friday, April 16, the President, Major William Gregson, M.Sc., announced two matters of interest. He said that the late James Clayton, who had been such a munificent benefactor to the Institution, had given the greatest freedom to all concerned in the operation of his gift. He had expressed the hope, however, that a snapshot photograph of himself might be hung somewhere in the Institution. This had been done, but they had also arranged for an artist to paint a portrait from the photograph. The President drew the attention of members to the portrait, which had been hung below the gallery at the back of the hall. Major Gregson also announced that the Council had elected Professor F. C. Lea, O.B.E., D.Sc., Wh.Sc., President of the Institution in 1943, to honorary membership. Dr. Andrews then presented his paper. He first gave a useful review of the work of previous investigators, in Europe, Russia, the United States and this country, on the testing of locomotives. Several methods had been adopted for maintaining constant the speed of a locomotive on the track, but on the L.M.S. Railway they were led to adopt electrical braking vehicles. There were three "mobile testing units," each of which was, in effect, a powerful motor-coach equipped for rheostatic braking only. The units were designed for maximum speeds of 50, 90 and 120 miles an hour, respectively; one, two, or three units could therefore be used, within certain speed ranges. The specification had called for an absorption of 51,500 lb. tractive effort between 10 and 22 miles an hour, and of 3,000 continuous horse-power between 22 and 120 miles an hour. The characteristic curves showed that they had fulfilled these requirements. The speed of the testing units was controlled automatically by a hot-cathode mercury-arc rectifier or thyratron, and the author had developed a type of flexible axle drive in collaboration with the English Electric Company. The drive, which was contained in a gearwheel, consisted of four links and a floating member, and connected the gearwheel to a disc crank mounted on the axle. It did not introduce any angular discrepancy between the relative positions of the driving and driven members—a feature which was valuable in reducing wear at high speeds. A special tender for measuring the consumption of coal and water had also been built, and a new dynamometer car, which, in addition to the usual functions, would also be used as a control car for the braking coaches, was under construction. An anemometer for measuring relative wind velocity, and a wind-vane for indicating relative wind direction, were carried on a frame projecting from the front of the locomotive, and the velocity and direction were recorded by pens in the dynamometer car. The mobile testing plant had been used for certain tests, with an existing dynamometer car, and Dr. Andrews cited some of the many purposes to which the plant might be put: the measurement of performance of steam, Diesel and electric locomotives, the resistance of rolling stock, the coefficient of friction during wheel slip, the creep of tyres, etc. It was also valuable to be able to simulate the effect of the profile of one section of track, where a particular locomotive was not permitted to run, on another section of track where it was permitted. In the discussion which followed, several speakers, some of whom had been associated with Dr. Andrews, made contributions to the subject.

THE INSTITUTE OF MARINE ENGINEERS.

The great activity prevailing in all branches of British maritime industries during 1947 was reflected in the work of the Institute of Marine Engineers last year. The steady growth in the membership has continued, there being 5,503 names on the roll on December 31, 1947, as compared with 5,129 on the previous January 1, these figures representing a net increase of 374. In their annual report for the year, the Council record with regret the death of 49 members, among whom were Sir S. George Higgins and Major-General The Right Hon. Lord Mottistone, both past presidents; Mr. R. S. Kennedy, an honorary vice-president; Mr. A. R. T. Woods, a vice-president; and Mr. Frank Cooper, a past member of Council. Thirteen papers were presented and discussed at meetings held during the year, and, in addition, the Executive Committee of the Education Group of the Institute, of which Mr. C. W. Tonkin was elected chairman on May 16, 1947, arranged 17 lectures which were delivered during the winter months in Belfast, Sunderland, Swansea, Cardiff, West Hartlepool, Gillingham (Kent), and Greenock, as well as at various centres in London. Some repairs to the lecture hall and the library of the Institute's headquarters were carried out last autumn and the James Watt window was removed from its war-time storage and replaced in its former position. On December 31 last, the total of the contributions made to the Marine Engineers' National War-Memorial Building Fund was 49,582*l.*, and the Committee are now engaged in a renewed campaign to raise this figure to the sum of 100,000*l.*, which has been fixed as the minimum objective to finance the scheme as originally planned. After the lengthy consideration of representations put forward by the vice-presidents at Cardiff and Swansea, the Council have agreed to the formation of local sections of members resident in those areas. New rules are being formulated under which the activities of the new sections will be conducted. For some time past a desire has existed among members of the Institute and those of the Institution of Naval Architects for closer co-operation and the co-ordination of their policy and activities, in view of the many interests common to shipbuilders and marine engineers. As the result of consultations between the two Presidents, a joint committee with equal representation of the two institutions has been formed to consider means of implementing the proposal.

INSTITUTION OF CHEMICAL ENGINEERS.

That the question of education in chemical engineering occupies much of the attention of the Council of the Institution of Chemical Engineers is indicated by the space devoted to this matter in the annual report of the Council for 1947 presented at the twenty-sixth annual corporate meeting of the Institution, held at the Connaught Rooms, London, W.C.2, on April 16. One matter of interest mentioned is that the special short-term full-time courses in chemical engineering, which have been under discussion for some time past, were established during the year under review by the Ministries of Education and of Labour and National Service, at Battersea Polytechnic, the South-West Essex Technical College at Walthamstow, Loughborough College, and Bradford Technical College. Discussions with the Ministry of Education on the question of the possibility of the foundation of National Certificates have been continued. While it appears to be not yet practicable to establish such certificates, an agreement has been reached with the Ministry and the Institution of Mechanical Engineers, under which Ordinary and Higher National Certificates in Mechanical Engineering may be endorsed with regard to extra subjects taken and countersigned by the Institution of Chemical Engineers in respect of chemical engineering subjects. Particulars of the scheme have appeared in our columns and fuller details will be found on page 447 of our issue of November 7, 1947. At the luncheon which followed the meeting, Sir Edward Appleton, G.B.E., K.C.B., F.R.S., in proposing the toast of the Institution, stated that a chemical engineer should possess not only knowledge and insight but resource and an insatiable scientific curiosity which would prompt him to make discoveries. The response to the toast was made by Mr. H. W. Cremer, who, that morning, had been re-elected for a further year of office as President of the Institution. In the afternoon, Mr. Cremer delivered his presidential address, which dealt with "The Chemical Engineer and Civilisation." The address is reprinted on page 390 of this issue.

INTERNATIONAL CLOSED-CIRCUIT SPEED RECORD FOR AIRCRAFT.

The de Havilland Aircraft Company have announced that, subject to confirmation by the Fédération Aéronautique Internationale, the international speed record around a closed circuit of 100 km. was raised to 605·23 miles an hour on Monday, April 12, by a de Havilland DH 108 aircraft. The speed attained is more than 40 miles an hour faster than that set up recently by the Vicker's Supermarine Attacker aircraft which, in turn, obtained the record from a Gloster Meteor. The aircraft was entered jointly by the Ministry of Supply and the de Havilland Aircraft Company, Limited, Hatfield, Hertfordshire, and was piloted by Mr. John Derry, D.F.C., an experimental pilot of the de Havilland team. An interesting feature is that the DH 108 is not a machine designed specially for record breaking, but is an aircraft of relatively light wing loading which has been designed for development work in connection with the DH 106, a projected pure-jet transport machine. Actually, the wing loading of the DH 108 is lower than that for the Vampire fighter, a machine of comparable size and fitted with the same type of engine, namely, the Goblin. The engine fitted to the record-breaking machine, however, is of the latest mark; unfortunately the output of this engine may not be disclosed, but it can be stated that it is considerably more than the 3,300 lb. static thrust developed by the Mark 3 Goblin, now in production. The DH 108 aircraft which achieved the record is one of three tailless machines which have been built for research purposes, primarily the investigation of control characteristics of the swept-back wing at high and low speeds. An illustration of the aircraft appeared in ENGINEERING, vol. 162, page 283 (1946), but beyond the span and length, which are 39 ft. and 24 ft. 6 in., respectively, the de Havilland Company are not permitted to release any further information. The course used for the flight was an irregular pentagon and was chosen for the distinctiveness of the landmarks. The turns ranged from 65 to 90 degrees and were taken at approximately $3\frac{1}{2}g$, so that inevitably some distance was lost at each turn.

INSTITUTE OF FUEL.

The report of the Council of the Institute of Fuel for 1947, was presented at the annual corporate meeting which was held at the Connaught Rooms, Great Queen-street, London, W.C.2, on Thursday, April 22, with the President, Dr. C. H. Lander, C.B.E., in the chair. An active year was recorded. On June 5, 1947, the Lords of His Majesty's Privy Council had allowed the first by-laws, made at the special general meeting which was held earlier in the year; the Institute thus attained the full status of Incorporation by Royal Charter. A subcommittee, under the chairmanship of Mr. H. E. Partridge, had considered the desirability of formulating a national fuel policy, and, as a result, the Council had made representations to the Prime Minister and the Minister of Fuel and Power, urging the most careful examination of the problem at the highest level. In reply, the President had been assured that the Minister of Fuel was charged to formulate a national fuel policy, but that it was not considered possible to detail such a policy until all the major fuel industries had been brought under public control. In collaboration with the Institute of Petroleum, arrangements were in hand for a conference on "Modern Applications of Liquid Fuels," to be held at Birmingham University in September, 1948. The successful conference on pulverised fuel, held at Harrogate in June, 1947, was briefly recorded; the 60 papers presented at the conference were collected subsequently in book form, and copies were still being sold. The Council expressed gratification that the present total of 18,740*l.* for the Building Fund was within 6,300*l.* of the target, but urged all members should contribute something to the Fund if only small amounts. Between March, 1947, and March, 1948, the total membership, excluding collective members, increased from 2,732 to 3,027; including collective members, the corresponding figures were 2,893 and 3,193. Dr. Lander, who is continuing in a second year of office as President, delivered his second presidential address immediately after the meeting.

OBITUARY.

CAPTAIN E. W. SWAN, O.B.E.

On page 376, *ante*, we recorded briefly the very sudden death, while on a journey to London, of Captain E. W. Swan, O.B.E., R.N.V.R. (ret.), curator (and largely the creator) of the Museum of Science and Industry, Newcastle-on-Tyne. Captain Swan, who was 64 years of age, was the second son of Colonel Swan, C.B., M.I.C.E., a director of Sir W. G. Armstrong, Whitworth and Company. On leaving Harrow, he was articled to the same firm, eventually becoming outside manager in charge of all naval guns and mounting. He was one of the first to join the Tyne Division of the Royal Naval Volunteer Reserve on its formation in April, 1905, and, 24 years later, became its commanding officer. On the outbreak of war in 1914, he was appointed to the Admiralty for special service. Subsequently, he served in the battleships Agincourt and Canada, among other vessels; was closely associated with the heavy repairs to the main armament of the battle-cruiser Lion after the Jutland battle; and was concerned in the work of transferring the heavy guns from an assortment of other vessels into several of the larger monitors. On the establishment of the Museum of Science and Industry, some 16 or 17 years ago, Captain Swan undertook the duties of curator, a post for which he was admirably fitted by temperament and by his extensive knowledge of north-country industries. He returned to active service during the recent war, mainly in shore appointments. He was a Deputy-Lieutenant for the county of Northumberland, a former naval aide-de-camp to King George V and King Edward VIII, a member of the Committee of Management of the Royal National Life-Boat Institution, a member of Council of the Newcomen Society, and an associate-member of the Institution of Naval Architects. While commanding the Tyne Division, R.N.V.R., he compiled and published, in 1939, a small book on *The First Commission of H.M.S. Calliope*, the Division's headquarters and drill ship which, in 1889, during that commission, escaped from the harbour of Apia during the hurricane which wrecked every other ship in it.

MR. PERCIVAL MARSHALL.

We also recorded, on page 376, *ante*, the death, on April 10, of Mr. Percival Marshall, head of the technical publishing firm bearing his name, and editor for 50 years of *The Model Engineer*.

Percival Marshall, who was born in 1871, was one of three engineering brothers, grandsons of the William Marshall who had the distinction of being the first man to set up a bookstall in a railway station; the other brothers were Reginald, who was for many years on the construction staff of the former British Petroleum Company, and Alfred William, of whom an obituary notice appeared on page 95 of our 154th volume (1942). Like his brothers, Percival was a student at the Finsbury Technical College, where he gained a Mitchell Scholarship of 60*l*. This, as he related afterwards, changed the whole course of his life, for his early leaning had been towards the trade of an engraver on wood. Instead, he continued on his engineering course, and, in 1887, entered upon an apprenticeship with Messrs. R. Hoe and Company, subsequently served in part with Messrs. Alfred Herbert, Limited, Coventry, and with the firm of Messrs. Goodbrand and Holland, in Manchester. While in Manchester, he continued his studies by attending Owen's College. In 1891, he worked for a time as a draughtsman with Messrs. R. Furnival and Company, of Stockport, makers of printing machinery and gas engines; but returned to London in 1892 to join his elder brother, Alfred, in an electrical-engineering business which later became the Crypto Works, in Clerkenwell. His next post was in France, where he spent a few months with Messrs. Hermet and Piquet, of St. Aubin; but towards the end of 1894 he changed his employment completely, becoming a sub-editor of a trade journal, *The Hardwareman*. His aptitude for journalism must have been very evident, as a year later he was made editor of *The Photographic News*, an appointment which was notably successful. In January, 1898, however, he decided to set up as a publisher on his own account and founded *The Model Engineer*. The interest aroused by this venture led to the foundation of the Society of Model and Experimental Engineers, of which he was the first President and which is to celebrate its 50th anniversary in May by an exhibition at the Imperial Institute, as mentioned on page 387 of this issue. Some 40 model clubs are now affiliated to it, and there will be widespread regret that Mr. Marshall, who was personally known in practically all of them, did not live to this second jubilee in his long association with model engineering. Among his fellow-publishers he was equally well known, having been chairman of the Periodical Trade Press and Weekly Newspapers Proprietors' Association for 15 years until, in 1943, he was elected a vice-president.

LETTER TO THE EDITOR.

THE INSTITUTION OF MECHANICAL ENGINEERS.

To the Editor of Engineering.

Sir,—Circumstances prevented me from attending the special meeting of the Institution of Mechanical Engineers on April 8, called to consider proposals for increased subscriptions, but if what I hear of it is correct, it would seem that the Council and officers have learned nothing from their experiences in connection with the amalgamation with the Institution of Automobile Engineers.

To suggest an increase in subscriptions at a time when the stabilisation of wages, profits and dividends is asked for by the Government and all thinking people seems the quintessence of bad generalship, especially when it is supported by a former President who, not long before, had called attention to the difficulties of a large body of members (the older ones) so far as employment is concerned. In his request for increased support for the Benevolent Fund of the Institution, Lord Dudley Gordon also cited the troubles of the younger members; yet, immediately after his appeal, we have thrust at us a considerable addition to our subscriptions. It appears that the handling of the meeting at which this came up was reminiscent of a shareholders' meeting with a board of directors secure in their voting power rather than of a meeting of the premier mechanical engineering institution.

I wonder whether the Council and officers of the Mechanicals realise that it was only the fact that 1947 was the centenary year of the Institution which prevented a motion being put forward at the extraordinary general meeting a year ago, requiring fuller particulars of the expenditure in view of the increase shown in the accounts. I, personally, would have moved such a resolution had it not been such an important year in the history of the Institution. A seconder was available and I feel sure that the motion would have stood a good chance of prevailing.

The Institution belongs to the members, but, as is so often the case in industry and elsewhere, the trend of circumstances is for the proprietors to be pushed on one side by the executive. We see this in parish councils, in rural district councils, in county councils and in Parliament. It is time that a halt should be called when the same tendency infects engineering institutions. I trust, therefore, that the members will refuse to vote for an increase in the subscription rates unless and until better reasons for the present cost of operating the Institution have been furnished to them.

Yours faithfully,
Kyrle W. Willans.

Shattrick,
Broadway, Ilminster, Som.
April 11, 1948.

[Commander Willans is aware, but the fact should be emphasised to prevent any misunderstanding, that the proposer of the motion which resulted in the extraordinary general meeting a year ago, to which he refers, was careful to explain that he did not question in any way the accuracy of the auditor's certificate appended to the accounts under discussion.—Ed., E.]

THE INSTITUTION OF NAVAL ARCHITECTS.

(*Concluded from page* 378.)

At the morning session on March 19, in the three-days Spring Meeting of the Institution of Naval Architects, the two papers presented were by Mr. Anthony Reid, B.Sc., on "Temporary Hull Repairs to the Tanker Markay"; and by Professor T. H. Havelock, F.R.S., on "Calculations Illustrating the Effect of Boundary Layer on Wave Resistance." Summaries of these papers, and reports of the discussions, are given below.

Temporary Repairs to Tanker "Markay."

The tanker Markay was severely damaged by running on shore on the island of Skye, about 200 ft. of the forward bottom plating and internal structure being torn away. She was a vessel of the normal tanker type, partly welded and partly riveted, with machinery aft, and measured 520 ft. in length overall. She was refloated and proceeded under her own power to Swansea, where temporary repairs were effected to enable her to cross the Atlantic to the United States for permanent repairs. She was kept afloat on the voyage from Skye to Swansea by the use of compressed air in certain of the damaged compartments. The damage extended aft from the bow to about one-tenth of the length forward of mid-length; but the deck sustained no damage and there were no failures of welds. The temporary repairs included the construction of a V-shaped bottom for about 75 ft. under the forepeak and the fore deep tank and the fitting of five deep longitudinal girders to take the place, for strength purposes, of the 500 tons of material torn away. One of these girders was on the centre line, one on the line of each of the two longitudinal bulkheads, and one on the line of the side shell on each side of the ship. The existing side shell and the longitudinal bulkheads, with the existing web frames and stiffeners, were plated down and attached to the respective girders, the five girders were cross-tied by channels at intervals of about 12 ft., and No. 4 starboard and No. 5 port tanks were made watertight. On the Atlantic voyage, compressed air was used in No. 3 tank only, the transverse bulkheads at both ends of this tank being plated down far enough to prevent loss of air pressure when the tank was over a wave hollow. To keep the air in other damaged tanks at atmospheric pressure, the ullage plugs in the tank hatchway lids were left open, though the lids themselves were closed and secured. By these means, when the ship left Swansea for the United States, most of the lost buoyancy had been restored and some of the strength of the structure had been replaced by the insertion of the five girders. In the paper, the author summarised the strength calculations relating to the ship in her temporarily-repaired state, under normal seagoing conditions, and the buoyancy conditions in similar circumstances. The vessel made the Atlantic crossing in ballast without misadventure and was permanently repaired in the United States.

Mr. J. Turnbull, opening the discussion, said that, from the penultimate paragraph of the paper, the impression might be formed that the American Bureau of Shipping had taken relatively little interest in the repair. The Bureau was concerned with the certification of the ship for the voyage in the unrepaired condition from Scotland to Swansea, at Swansea, it had made recommendations for temporary repairs and, when those repairs were completed, had issued a certificate for the voyage to the United States. The illustrations in the paper did not give an adequate impression of the magnitude of the damage. He believed that the decision to carry out such extensive repairs, merely for one voyage, was due to the acute shortage of dry docks in this country and the need to get the ship away as soon as possible; and he felt that that necessity had rather discouraged those concerned from considering how they could incorporate something of a permanent nature in the temporary repair. Though he was not responsible for the job, he was consulted in the early stages, and had proposed that No. 4 tank should be made good; that might have simplified the rest of the work and contributed to the

subsequent work on the other side. However, other counsels had prevailed.

In the paper it was stated that, as the damage to the ship extended so far aft, the amount of material to be built in as a temporary repair was of some importance; and that it was proposed to make the total cross-sectional area of the five girders not less than 25 per cent. of the cross-sectional area of material torn off. The proposal was approved by both classification societies and had proved acceptable to the underwriters and other parties concerned, but he did not subscribe to the statement that 25 per cent. of the cross-sectional area of the material torn off was sufficient; how could the calculations possibly justify a reduction of 75 per cent. on the rules of the classification societies? He suggested that the stresses tabulated in the paper were based on a theoretical figure which was not supported by practical considerations, and said that those responsible had not adopted 25 per cent. replacement of the cross-sectional area of material torn off; it looked as though they had put back 80 per cent. in No. 4 tank and about 50 per cent. in No. 3, which indicated that they did not believe the figures in the end.

Mr. H. Torrance said that his first reaction to the paper was that a wonderful transformation had been effected by a piece of neat workmanship; but that feeling was succeeded by disappointment that all the valuable steel in the work was to be torn out and thrown on to the scrap heap after the vessel had crossed the Atlantic. With a little change in the system of the repair, much of that work and material might have been saved. The centre-line girder, almost the full length of the ship, might well have been made to the correct scantlings and completed, so that the Americans could have left it and added the rest of the repair to it. The bulkheads could have been dealt with similarly; it would have needed more material in the first place, but would have resulted in an ultimate saving.

Mr. J. Burton Davies, referring to the docking stools, asked why it was considered necessary to make them so deep; surely a level surface at a known height above the base line could have been provided with considerably less expenditure of labour and materials? The centre-line seat under the forward deep tank was well within the pounding region, and, although strongly built, would appear to be liable to damage if heavy weather were encountered. He asked whether bad weather was experienced, and whether additional stiffening was fitted to the bulkheads at the fore end of No. 4 tank starboard and No. 5 tanks, centre and port. With regard to the use of compressed air in No. 3 tank, he asked which method was adopted. With method "A," once No. 3 tank had been opened to the sea the buoyancy effect of the air in that tank became the same as in method "B," and the only difference between those conditions would be the bending moment due to the extra 410 tons of ballast originally taken on board for method "B." Presumably, that additional ballast would be in the 'midship tanks, and, therefore, would increase the sagging moment; for that reason, method "A" would seem to be preferable. On the other hand, the conditions in method "B" were independent of whether or not No. 3 tank was opened to the atmosphere.

Mr. R. B. Shepheard thought it of interest that the material, although so badly damaged, had shown no sign of any general brittle structure. He had gathered also that, when the ship went ashore, there was no fracture of the welds or other structural damage apart from the bottom of the ship in contact with the rocks. He also asked what were the weather conditions, the general behaviour of the ship, and her speed, on the Atlantic crossing. With the tanks open to the sea, the docking keel added, and possibly the effect of additional resistance due to the open bottom structure, her behaviour and performance at sea were probably very different from the normal. The paper indicated the additional responsibility which had been thrown upon a very busy surveyor under war-time conditions, and the conditions which those responsible for repair work during the war had had to face. In the present instances, a great deal of necessary additional work was done by the author in going into strict calculations.

Mr. M. M. Parker said that apparently the assumption was that, if the lids of the tanks were closed and the ullage plugs were open, the pressure was atmospheric. Taking the ordinary period of pitching of the ship, it seemed very doubtful whether the air could get out of those comparatively small orifices at the same speed as that at which the ship pitched. He asked for the author's comments on the matter.

Mr. D. Turner also asked for information as to the ship's behaviour on her Atlantic voyage, the length of time taken in crossing, the weather experienced, the condition of the temporary repairs on arrival, and the sea speed of the ship normally and in her temporarily repaired condition. He inquired also what was the time occupied in carrying out the repair, and the cost; and whether any temporary repairs were effected before the ship left Skye. Considering the abnormalities of the time (1944) and the experiences of many other crippled ships in troubled waters, and remembering all the intact spaces aft of the No. 4 cargo tanks, he wondered whether the risk would have been too great had the ship been taken across the Atlantic with the under-water portion of her forebody torn.

Mr. Reid, in reply to the discussion, agreed with Mr. Turnbull's remarks with regard to the American Bureau and his own and his colleagues' share in the work. Mr. Turnbull had questioned whether the theory used should have been applied to that ship; Mr. Reid did not know whether Mr. Turnbull had some other theory that he would apply, whether it would have given different answers, or whether, having obtained those different answers, he would have done anything more about it; but, as he had issued an interim certificate, probably he had made some calculations. Had Mr. Turnbull arrived at the same stresses as those shown in the paper?

Mr. Turnbull said that he and his colleagues were prepared, for the purposes of the voyage, to take something of the order of 80 per cent. of the cross-sectional area of the material torn off, but were not prepared to accept 25 per cent.

Mr. Reid replied that the calculation was fairly justified. He admitted that there was more than 25 per cent. at No. 4 tank; but the proposal was to put 25 per cent. of the cross-sectional area into the girders; nothing was said about end attachments or the longitudinal bulkhead fittings. As to the reasons why such an extensive repair was carried out for one voyage, he said that, in the first place, the shell of the ship was not quite all-welded; the seams were all-welded and the butts were riveted, and the superintendent would not accept a repair which would not put the ship back into the condition which had existed before she was damaged. At Swansea they had not the welders and it was stated that welders could not be spared from other ports.

Dealing with Mr. Torrance's suggestion that the centre-line girder would have been better if made of the same scantlings as the original and brought along the original base line and attached to the docking seat, Mr. Reid said it might have been all right; but there was a centre-line bulkhead in the fore deep tank, and there was some stiffening of the scantlings to take the pull from that girder. Again, they were rather tied in respect of the material they could obtain; they had had to take more or less what was in stock, and it was easier to accept the material there than to try to obtain special material just for that one job. The problem of dealing with the bulkheads in the same way was further complicated by the fact that the longitudinal and transverse bulkheads in the ship were of special corrugated type, and he imagined it would have been quite impossible then to have made them in Swansea.

On Mr. Davies' question why the docking seats were made so high, he said that, when the ship was first put into dry dock, it was not certain whether there would be any permanent or temporary repairs made at all. As to the use of compressed air in No. 3 tank, condition "B" was the one used; the ullage plugs on No. 3 tanks, port, starboard and centre, were closed and the ship was ballasted. At first, they had not intended to use compressed air, but the superintendent thought it wise to have at least one tank closed so that, if anything happened in the fore peak, there would be some buoyancy.

There was not a great deal of information about the voyage. The weather was reported to be normal for the time of year, but the draught forward was rather small—18 ft.—and the draught was increased by taking on ballast; how much, was not stated. In reply to Mr. Parker, it was a question of whether to leave the lids open altogether or to leave only the ullage plugs open, and it was felt to be better to shut down the lids. The condition of the repairs on the arrival of the ship in America was said to be just the same as when she had left Swansea. The work had occupied about four months and the cost of the repairs was about 66,000*l*. No repairs were done before the ship left Skye. After the ship was first damaged she was brought to the Clyde, and there she was examined only by divers and was not put into dry dock; he thought it was not really known then how much damage she had suffered.

The Effect of Boundary Layer on Wave Resistance.

In introducing his paper, which was not read *in extenso*, Professor Havelock explained that its main object was to examine the possible effect of the boundary layer in producing a virtual modification of the lines of a ship near the stern. He considered this to be, in effect, a deflection of the streamlines caused by the increased displacement thickness of the boundary layer (a term which he illustrated by blackboard diagrams as being the difference in thickness between the flow if there were no friction and the flow as reduced by friction). He then indicated how, by superposing a source distribution to produce this additional deflection, expressions could be obtained for the modified wave resistance. No attempt was made to investigate the case of actual ship forms, but an indirect method was adopted. Some ideal simple forms being considered and small modifications of the lines near the stern being assumed, such as might be ascribed to boundary-layer effects. It was shown that such variations sufficed to eliminate the humps and hollows on resistance curves at low speeds while making, relatively, much less difference at high speeds. This result, Professor Havelock showed, would improve the general comparison between the wave resistances as calculated and as measured.

Mr. W. C. S. Wigley said that an immense amount of work was involved in the numerical calculations to produce the results shown in the paper, especially the calculations for the model with finite draught, but it was work that needed to be done, because very little was known about the change in the wave resistance resulting from the effects of viscosity and the boundary-layer effects. It was most interesting to note how small a correction, applied at the extreme stern, would cause cancellation of the extreme oscillation in the calculated wave-resistance curves at low speed. This was the main conclusion to be drawn from the paper.

Dr. S. Livingston Smith considered the paper to be an important one, expert mathematical analysis having provided some exceedingly practical results. The large oscillations computed in resistance curves by mathematical methods had not been confirmed experimentally, as the author had said. While it was known that viscosity was probably the cause of damping out the pronounced oscillations, it was comforting that Professor Havelock had been able to show mathematically that the effect could be accounted for by boundary-layer effects on wave resistance. As to the possibility of correcting skin-friction plank tests for the effect of wavemaking, the author had described his results as no more than rough approximations; could those calculations be refined, without undue labour, for a particular plank and thus made to serve a directly practical purpose? For example, the author had assumed that the wave resistance was proportional to the square of the beam, whereas tests with merchant forms had tended to show that the variation was less marked; that would have a marked effect on the proportion of wavemaking resistance to frictional resistance. Although it was generally assumed that skin friction and wavemaking were independent, the assumption was worthy of close investigation. The British Shipbuilding Research Association were arranging for tests to be made towards the elucidation of that problem. A reflex or double model was to be tested in the largest wind tunnel at the National

Physical Laboratory. The resistance would be recorded, pressures would be measured on the surface of the hull, and transition lines would be determined. Further tests in water with a similar single model would show the effect of free surface and provide a useful check on those fundamental assumptions which had been made from the first inception of model tank tests. The comparatively new aeronautical technique of obtaining drag or resistance measurements by Pitot-tube traverses behind the hulls would also be employed.

Mr. J. R. Shearer asked whether the improved agreement which the author had shown between measured and calculated curves of resistance necessarily implied that the wave motion was more correctly represented.

Professor Havelock, in reply to the discussion, said that he claimed the privilege of a theoretical person to think about the questions raised and to reply in writing; and he hoped the speakers would regard that as a compliment.

At the afternoon session of March 19, which concluded the 1948 Spring Meeting of the Institution, two papers were presented, these being by Mr. R. T. Shiells, B.Sc., on "Small Model Experiments and Viscosity Effects," and by Mr. J. McCallum, B.Sc., who gave the results of "An Examination of the Pressure Distribution over a Model Hull."

Small Model Experiments and Viscosity Effects.

Mr. Shiells described experiments carried out with a 4-ft. model, made by himself, when towed by means of a line and falling weight. The resistance tests were performed in a covered swimming bath, and the photographic records which accompanied the paper were obtained on an outdoor static water tank under selected conditions of summer weather. The purpose of the tests was to determine whether there was any scale effect, for models of the order of 16 ft. in length, in the application of viscosity corrections to wave resistances and profiles, as carried out by Mr. W. C. S. Wigley. Mr. Shiells therefore repeated some of Mr. Wigley's experiments, but used a 4-ft. model. His series of tests included measurement of the resistances of an unsymmetrical model with the full end and the fine end leading (and hence a difference in the © value when the motion was reversed); and the plotting by photography of the wave profile of a simple symmetrical 4-ft. model. The apparatus used was described, together with the means adopted to secure turbulence at low Reynolds numbers. The reversal tests showed that the © difference became nil at substantially the same relative speed as with the 16-ft. model, and the profile tests also agreed closely, indicating that the viscosity effect on wave formation was nearly independent of scale.

Mr. W. C. S. Wigley said that Mr. Shiells was that typically English product, an enthusiastic amateur; it was difficult to conceive of a skilled amateur in any other country taking the trouble to carry out such experiments, from sheer interest. In the history of naval architecture, there were records of many famous scientists who had started in a similar way; after all, Froude himself had started as an amateur. With regard to the experiments, it was not practicable to increase the scale largely, but it was possible to reduce the scale, as Mr. Shiells had done, and the empirical method of correction appeared to apply as well to a 4-ft. model as to the 16-ft. model from which it was originally derived. From that, it seemed reasonable to say that the same would apply for a longer model, especially as the effects on viscous forces of shortening from the 16-ft. model to a 4-ft. model would be very much greater, in general, than the effect of increasing the scale four times. The paper proved some interesting theoretical points, quite apart from showing that useful results could be obtained from 4-ft. models.

Dr. G. S. Baker, in a written contribution which was read by the secretary, referring to the author's reference to viscosity damping the bow wave, asked how that happened, or whether the author had meant surface tension. Some observations by Kent, which had never been published, suggested that under certain conditions surface tension did affect the bow wave. It was interesting to use a small model and to disturb the surface by small ripples to break the surface tension.

Mr. H. Lackenby said that Mr. Shiells had used a speed corresponding to a given towing force applied by a loaded line and a wheel. In calculating the resistance of the model from the driving weights, a constant deduction for mechanical friction had been used throughout, and Mr. Lackenby asked whether investigations had been made to determine whether the friction varied with the loading. He mentioned the matter particularly in view of the relatively high value of mechanical friction compared with the measured resistance.

Mr. Shiells, replying to Dr. Baker's question, said that presumably the effect of viscosity would be to cause a diminution of the amplitude as the bow wave travelled backwards, so that the amplitude would not be so great for purposes of interference at the stern. Replying to Mr. Lackenby, he said that the increase of friction with load was a matter about which he had been somewhat concerned, and he had plans for a future model where the friction of the wheel and the weights would be a constant. He felt quite certain that there was a slight increase of friction with load.

Pressure Distribution Over a Model Hull.

Mr. McCallum's paper described tests with a ship model in a wind tunnel, the primary purpose being to investigate the pressures acting on the model hull at a given wind speed and to plot these on the body plan. An attempt was made also to estimate the form resistance (or pressure resistance) and the frictional resistance of a similar full-scale vessel in water. It was an incidental purpose of the work to show that, in estimating the form resistance and the frictional resistance, these two major types of resistance could not be regarded as independent of each other. In calculating the frictional resistance of a full-scale ship, however, Mr. McCallum observed, the estimation of roughness was the real difficulty; it was possible to measure the roughness of a sample of plate, suitably coated, but how far this represented the mean roughness of the entire shell was a matter for speculation. It was probably safer to assume that all newly-scaled and coated vessels of the same type of shell construction (for example, welded or riveted) would have the same roughness, with varying roughness ratio depending on the length.

Mr. W. C. S. Wigley said the difference between a free surface and a fixed boundary affected, for instance, the virtual mass very seriously indeed, and he felt that it must affect everything. That was shown up to some extent in connection with the tabulation by the author of the pressure resistances.

Mr. L. J. Rydill commented that the author, while recognising the desirability of using a double model, considered that the single model with extended shell lines, actually used, would not appreciably affect the results. He asked if that remark were based on any experimental or theoretical evidence, and if the relatively small extension of the model above the load water line was sufficient to ensure that the effect of the flow over the top of the model was negligible. It was difficult to judge the reliability of the quoted pressure resistance of 0·005 lb. without knowledge of the limits of accuracy of the pressure measurements and of the integration, as any error was likely to be magnified by the fact that the pressure resistance was obtained from the difference of the positive and negative longitudinal components on normal pressure. In view of the extremely small value of the calculated pressure resistance, it could be argued that the experiments showed that resistance to be negligible in the fine model tested. He suggested that the author had been rather too ambitious in the application of his results, which were not really sufficient to justify an examination of the full-size performance. The discussion on roughness allowances introduced was quite out of place in that paper. Again, he suggested that the usefulness of the paper would have been increased had the author used one of Mr. Wigley's mathematical models, for which both theoretical and tank results were available, and had measured the total as well as the pressure resistance. That would have permitted a number of interesting and valuable comparisons.

Mr. T. Jaroszynski recalled that Dr. Baker, when investigating the discrepancies in frictional resistance of planks and ship forms, had in fact experimented on two models in a wind tunnel, reference to which was made in a paper read before the North East Coast Institution of Engineers and Shipbuilders in 1915. It was to be regretted that limited facilities had prevented Mr. McCallum from using a double-inverted model. If it could have been possible to measure the total resistance of such a model in a wind tunnel, the method of calculating form resistance developed by the author could have been given an acid test, and no objection could be raised that the flow pattern around the air and water model might not be similar. It was emphasised that the primary object of the test was to obtain a plot of pressure distribution over the ship's model, and that object had been admirably achieved. It was interesting that the average increase of velocity of flow around the hull compared favourably with the figures obtained experimentally by Dr. G. S. Baker (*Trans. I.N.A.*, 1913) and theoretically by Professor Havelock (*Trans. I.N.A.*, 1920). The method used for obtaining the pressure resistance of the model from the readings seemed perfectly logical, though it involved a great amount of arithmetical work.

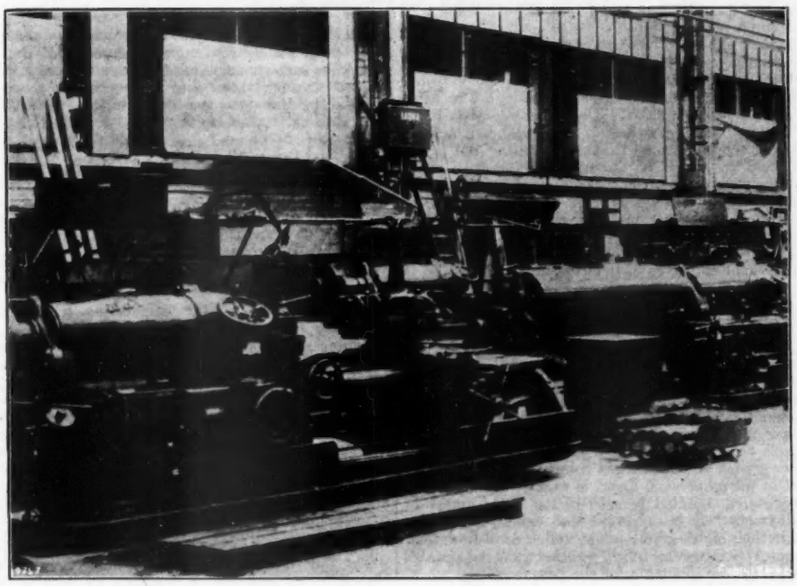
Difficulties arose when the model results were to be extended to the full-size ship. He disagreed with the author that the free-surface effect, which was absent in the wind-tunnel work, could be disregarded in surface ships. Secondly, the author's extrapolation of model results by means of an imaginary water model did not seem to be fully warranted, as it had been agreed already that the pressure resistance should be somehow related to Reynolds number, although he appreciated that only Froude's law enabled the author to compare his results with the tank results. It was not surprising, therefore, as the author had stated, that the pressure resistance might be over-estimated; and perhaps it was too early to make too conclusive predictions before more was known about the laws of mechanics of viscous fluids and the effect of boundary-layer differences on the pressure field of the model and the full-size ship. There was great scope for research in that field. Work in a wind tunnel had serious limitations, as, among other things, wave effect could not be studied, whereas it could not be disregarded in surface ships. The circulating water channel was particularly suited to that type of work, but unfortunately, there was no such installation in this country. The problem of ship-hull roughness was a very thorny one and no really satisfactory solution had yet been reached. In view of the complexity of the whole problem, he felt that the author's approach might be too simplified. How far tank results applied to full-size ships was not certain; in attempting to estimate the roughness coefficient of the hull, it was necessary to look to the full-size ship rather than to the model.

Mr. L. Woollard, supporting Mr. Wigley's remarks regarding the connection of the paper with resistance, said that, if a ship moving on the sea had a perfectly smooth plane on the water line, moving with the ship, the water pressures below the plane at the bow and the stern were very much reduced; but as soon as waves were allowed to form, the pressures were considerably modified, although they might be still high where they were previously high, and so on. In other words, he could see no direct connection between residuary resistance and pressure measurements on a model in a tank. He felt that the author must confess that difficulty.

Mr. McCallum intimated that he would reply to the discussion in writing. The 1948 Spring Meeting then concluded.

Exhibition of Old English Tools.—An exhibition of old English tools used by the carpenter, joiner, wheelwright, coachbuilder, cooper and millwright during the Eighteenth and Nineteenth Centuries will be held in the Hertfordshire County Museum, Hatfield-road, St. Albans, from Monday, May 3, until Saturday, June 19. The tools are from the collection of Mr. R. A. Salaman, and explanatory and historical notes are to be given. A few modern factory-made tools will be shown also for comparison. The exhibition will be open daily from 10 a.m. until 4 p.m., Fridays and Sundays excepted. The hours will be extended on Saturdays until 8 p.m.

INDUSTRIAL RADIANT HEATING.



INDUSTRIAL RADIANT HEATING.

ALTHOUGH radiant-heating systems have been used in hospitals, public buildings and offices for some time, it is only recently that this form of heating has been applied to factories. Radiant heating offers many advantages over other forms of heating, the most outstanding of which is the even heat distribution. Generally, radiant-heating installations take the form of pipe grids embedded in the ceilings during the construction of the building, the heating medium being circulated through the grids. The incorporation of embedded grids, however, is not always practicable, particularly in shed-type buildings having roofs of light construction, and as an alternative, Messrs. Richard Crittall and Company, Limited, 156, Great Portland-street, London, W.1, have developed the Sunzway radiant-heat panel unit. This consists of a steel panel to which is welded a sinuous pipe, the back of the panel being treated so as to reduce heat diffusion and thus render the provision of additional insulating material generally unnecessary. When the panels are fixed clear of the ceiling or wall, however, thermal-insulating material should be applied to the back of the panels to prevent excessive cooling by air circulation.

Sunzway panels are made in two sizes, namely, 8 ft. by 4 ft. and 6 ft. by 3 ft. The panels may be fitted in either the vertical or horizontal positions and the photograph reproduced above shows a group of vertical panels installed recently in the machine shops at the Lincoln works of Messrs. Ruston Bucyrus, Limited. In this particular installation, the panels are double sided, the heat being radiated towards the centres of adjacent bays; altogether five bays having a total floor area of 127,200 sq. ft. are heated by Sunzway units. In order to counteract the cooling effect of open doors, additional heating is provided at the ends of each bay, and this is accomplished by increasing the number of vertical units as well as the provision of overhead units. The latter are fitted also in the materials store as radiation from vertical units would be impeded by the materials and equipment in the stores. Radiant heating is used also to assist in the drying of paint. Usually the radiant-heating units are arranged so as to form a tunnel through which passes an endless conveyor. The size of the parts, however, prevented this method from being adopted at the Ruston Bucyrus works, and, as an alternative, Sunzway units have been fitted to the walls of the paint shop, the units being set at an angle to the walls so that they incline towards the equipment to be dried.

When radiant heating units are fitted to both sides of a workshop bay, automatic temperature control can be arranged so that excess air temperature actuates a sensitive element situated in the centre of the bay and closes down a series of units either on one or both sides of the bay. When the units are opened up again, the heating effect is restored almost immediately, as the heating capacity of a radiant-heating unit is dependent on its surface temperature. This feature enhances the value of the system when used in workshops where doors are being opened and shut continually, because although cold air is admitted, the radiant heat reaches the occupants all the time. Another feature is that when it is required to occupy only a section of a workshop during overtime periods, only those units covering that particular section need be brought into use, as the degree of warming is independent of the air temperature of the remainder of the shop.

The emission of radiant heat, however, is not confined to the use of pipe grids heated by steam or hot water, as the Dulrae Manufacturing Company, Limited, 156, Great Portland-street, London, W.1, a member of the Richard Crittall group of companies, manufactures electrical radiant-heating equipment. Three systems are available, namely, the Dulrae, the Medrae and the Hirae. The Dulrae system employs low-temperature radiation from the ceiling, the radiating element consisting of a flexible fabric in which the conductors are woven. It is manufactured in rolls 2 ft. wide and 300 ft. in length, the conductors being arranged so that panels can be cut in multiples of 2 ft. up to a maximum convenient length of 12 ft. The fabric is enclosed in fireproof plaster boards let into the ceiling and can, therefore, be rendered invisible. The radiating surface operates at a comparatively low temperature, usually between 80 and 90 deg. F., and temperature control is provided by an adjustable thermostat; obviously, this system is of more practical use in offices. The Medrae system employs medium-temperature radiation from the walls and the heating elements consist of panels constructed from a fibre-base material. The panels are bonded under heat and pressure with thermosetting phenolic resin, and nickel-chromium resistance wiring is embedded during this process. Medrae panels are usually mounted away from the wall so as to permit heating by air circulation in addition to radiation from the front face, but they can, of course, be employed as radiators only. When the headroom exceeds 10 ft., they can be fitted to the ceiling or, alternatively, when appearance is not of importance, they can be suspended from the ceiling or roof by chains. This system, like the Dulrae, can be controlled thermostatically and can be arranged for continuous or intermittent operation. The Hirae system is suitable for use in factories and stores where air changes are frequent, and in situations where local warmth is required as distinct from general warmth throughout the building. The rating for Hirae panels is 500 watts per square foot, and the surface can reach a maximum temperature of 500 deg. F. They are not suitable, therefore, for recessing into walls or ceilings but are intended to be mounted at high levels on brackets from the walls or suspended from the ceiling. The three different systems can, of course, be used together and it is common practice to fit both Medrae and Hirae panels in such buildings as works canteens, the Hirae panels being brought into use at meal times so as to supplement the heat supplied by the Medrae panels. Electrical radiant-heat units are particularly useful for heating those parts of a factory situated at relatively large distances from the main heating installation.

ILLUMINATION OF KING'S CROSS GOODS YARD.

RAILWAY goods yards are usually illuminated by gas-filled lamps of 200 watts to 500 watts capacity, mounted in enamelled-iron dispersive reflectors on wooden poles 20 ft. to 30 ft. high. The poles are placed so as to provide local illumination at places where the movement of wagons must be kept under observation, such as the shunting "neck" and hand-operated points. The London and North Eastern Railway also experimented, in the past, with horizontal projector lanterns with 500-watt to 1,000-watt lamps mounted on 40-ft. or 50-ft. poles. Neither the old system nor this experiment, however, is successful. The illumination provided by the former is uneven and causes glare, and the horizontal projector lanterns also cause glare. For a goods yard to be illuminated properly, the intensity of lighting should be fairly even and there should be no pronounced shadows. Bright sources of light near ground level create marked contrasts in lighting to which the eye will not readily adapt itself. Acuity of vision in an evenly illuminated area is sufficient, although the intensity of illumination may be comparatively low.

The King's Cross goods yard and locomotive running shed on the Eastern Region are now being provided with lighting designed on these principles. Experiments were carried out in 1946 by the London and North Eastern Railway. Two 60-ft. poles were erected: one fitted with 1,000-watt gas-filled lamps in prismatic lanterns arranged in a cluster of three, and the other with 400-watt mercury-vapour lamps similarly arranged. With the wooden poles sunk in the ground, the lamps were about 50 ft. above the ground. These experiments showed the superiority of lamps erected at this height, and it was decided to equip the whole yard with poles spaced 300 ft. apart approximately. About a third of the work has already been completed; progress is slow owing to the difficulty of obtaining even common materials. High-pressure mercury-vapour 400-watt lamps, in Holophane bi-way refractor lanterns, are arranged in clusters of three (120 deg. in plan). Since these lamps give a slightly green light, gas-filled lamps are being used in four cases where there is a risk of engine drivers confusing them with signals. The total number of poles, each with a cluster of three lamps, is to be 20, but there will also be about 23 other points where two lamps or one lamp will be mounted on a steel or wooden pole, or supported on a bracket; these are for local illumination of passages, bridges, etc. In the yard, the average illumination at ground level will be 0·25 ft.-candle.

The lamps are individually hoisted to the top of the pole by light wire ropes wound on hand winches fastened to the pole near the bottom. The lamps are held up by toggle-action clips which are released by pulling on the wire rope. Also mounted on the pole near ground level are two aluminium boxes, one housing three switches and the other housing the stabilising chokes. The main beam from each lantern is at 75 deg. to the vertical; thus, with the lamps 50 ft. high and 300 ft. apart, the whole area between is adequately illuminated. These dimensions are considered to be the best compromise; it would be necessary to provide elaborate structures if the lamps were to be erected any higher, and it would be difficult to find space between tracks for such structures. The cost of installing the arrangement of lamps that has been adopted, and the running costs, are also reasonable.

CONSTRUCTION OF BRITISH JET ENGINES IN ARGENTINA.—The Argentine Government have concluded a licence agreement with Messrs. Rolls-Royce Limited, for the manufacture of the Derwent gas-turbine engine in Argentina. The agreement was negotiated on behalf of the Argentine Government by the Instituto Aerotechnico Secretaria de Aeronautica, Cordoba, and was ratified by President Peron.

GENERATION OF ELECTRICITY.—The official returns rendered to the Electricity Commissioners show that 3,959 million kWh of electricity were generated by the authorised undertakings in Great Britain during March, 1948, compared with 3,984 million kWh during the corresponding month of 1947, a decrease of 25 million kWh, or 0·6 per cent. During the first three months of 1948, the total amount of electricity generated was 12,727 million kWh, compared with 12,335 million kWh for the corresponding period of 1947, an increase of 392 million kWh, or 3·2 per cent. The total amount of electricity sent out during the month of March, 1948, was 3,734 million kWh, compared with 3,760 million kWh in the corresponding month of 1947, a decrease of 26 million kWh, or 0·7 per cent. During the first three months of 1948 the total amount of electricity sent out was 12,025 million kWh, compared with 11,658 million kWh for the corresponding period of 1947, an increase of 367 million kWh, or 3·1 per cent.

ALUMINIUM-SHEATHED ELECTRIC CABLES.

LEAD has been employed for many years as a sheathing material for underground electric cables; and has many advantages for that purpose. It has, however, some drawbacks and investigations into the possibility of finding a substitute have therefore been in progress for some time. As a result, aluminium appears to be the most satisfactory alternative, owing to its lightness and strength. The high pressures and temperatures required for aluminium extrusion and the lack of other methods of applying a sound sheath have, however, been obstacles to successful manufacture. It is therefore of interest to learn that Messrs. Johnson and Phillips, Limited, Charlton, London, S.E.7, have now introduced power cables sheathed with commercial grade aluminium.

Although full details of the methods of manufacturing aluminium-sheathed cables are not yet available it may be said that the process developed by Messrs. Johnson and Phillips consists in threading the insulated core through a pre-extruded seamless tube of commercial grade aluminium. This tube is then swaged, so that an accurately fitting sheath is formed. The thickness of this is not less than 90 per cent. of the customary lead and lead-alloy sheaths and complies with the same tolerances as regards uniformity. Manufacture is effected in 200 to 450 yard lengths and in sizes up to 2 in. sheath diameter. The sheathing is applicable to all types of standard power cables.

The aluminium used for the sheath contains from 0·15 to 0·2 per cent. of iron and from 0·1 to 0·15 per cent. of silicon, together with smaller percentages of copper, magnesium and titanium, as well as a trace of manganese. Its specific gravity is 2·7 and its melting point 658 deg. C., the corresponding figures for lead being 11·3 and 326 deg. C. The result is that when aluminium is employed instead of lead a reduction in weight of from 25 to 60 per cent. can be obtained for unarmoured and of 20 to 35 per cent. for armoured cables. The tensile strength of the aluminium used is from 12,000 to 15,000 lb. per square inch, compared with 2,000 lb. per square inch for commercially refined lead and 3,500 lb. per square inch for the British Standard lead alloy B, which contains 0·85 per cent. of antimony. Its endurance limit (stress causing fracture after 10^7 cycles) is $\pm$7,000 lb. per square inch compared with $\pm$ 400 lb. per square inch for commercially refined lead and $\pm$ 1,300 lb. per square inch for the standard lead alloy. As aluminium is stable at temperatures of 100 deg. C. or more, re-crystallisation does not occur. It has a well defined yield point below which it behaves elastically, while its fatigue endurance and creep resistance are such as greatly to reduce any risk of failure owing to vibration, fluctuating internal pressures or alternating tensile stresses.

Aluminium-sheathed cable is, of course, more rigid than lead, owing to the greater toughness and strength of the metal. We understand, however, that tests have shown that it compares very favourably with lead when submitted to bending; and that, in particular, no difficulty has been experienced in reeling it on to drums of normal size or in installing it where sharp bends have had to be negotiated. These tests also indicate that the stresses set up during bending make it desirable to employ sheaths thicker than would be necessary solely from considerations of strength. In fact, the thickness of the sheath should only be about 10 per cent. less than that of a corresponding lead-sheathed cable. This, however, has the advantage that greater resistance is afforded to accidental damage. The mechanical characteristics of aluminium are also found to make for economy in installation and ensure that no permanent distortion of the sheath will occur owing to high internal pressures. This may render it possible for the maximum conductor temperature to be increased from the present value of 50 deg. C. for unarmoured lead cables in ducts to 85 deg. C. The result would be an average reduction in copper section of about 15 per cent. with a consequent saving in cost and weight.

An undoubted obstacle to the use of aluminium sheathing has been the difficulty of making soldered or sweated unions with that metal. A very large number of cable joints and terminations for low and medium tension cables, however, only require compound sealing, and this method can also be employed with aluminium sheaths provided precautions are taken to prevent contact with other metals. For totally-sealed joints or terminations Messrs. Johnson and Phillips have developed a mechanical type of union to replace the normal plumbing gland. This consists essentially of a pair of rings between which the sheath is gripped. These rings are coated with cadmium to exclude any risk of galvanic action. A lead or tinned-copper sleeve is then slid over the joint and plumbed to the fiittngs in the normal way and finally the completed joint is enclosed in a concrete or metal box filled with a suitable bitumen compound.

LABOUR NOTES.

IT is stated in the Information Service of the Ministry of Labour that a Leeds firm of electrical engineers, Messrs. The Yorkshire Switchgear and Engineering Company, Limited, has found that closer contact with their employees has helped them to get first-rate results from their efforts to increase home and export output. The management, it is stated, keep in personal touch with their employees, and all operators are informed about the firm's production needs, through a monthly production target chart. The chart consists of a collection of small drawings of the actual contracts, or sections, which must be turned out during the period and they are found to have greater incentive value than the more orthodox graphs and production marking boards. The drawings explain vividly the relative importance of the various jobs, and a good degree of balanced production has been secured. The most striking evidence of the value of the firm's close management-employee association is the fact that a 300 per cent. production unit increase on the pre-1939 output has been achieved with an additional labour force of only 200 per cent.

In another note, employers are reminded that the 14 Appointment Officers of the Ministry of Labour and National Service have on their books a number of registered disabled persons with professional, administrative or managerial qualifications, who are seeking suitable employment. These disabled persons in the higher grades of employment count towards the fulfilment of the employers' quota in exactly the same way as registered disabled persons in the lower grades of employment. It is suggested that employers seeking staff in their higher grades might well find out from their nearest Appointments' Officer whether there is a suitable disabled person available for the post.

At the end of March, the membership of the Amalgamated Engineering Union was 820,687—an increase of 11,053 compared with the number at the end of February. During March, 6,131 members received sick benefit—a decrease of 431; 20,246 superannuation payments—an increase of 79; and 1,223 unemployment benefit—a decrease of 47. The total number of unemployed members was 3,077—a decrease of 243.

Speaking at Birmingham recently, Mr. Morgan Phillips, general secretary of the Labour Party, said that the 1947 membership of the party was 4,685,699—an all-time record. Only twice before—in 1920 and 1921—had they exceeded 4,000,000. Last year's figure, which compared with 3,322,358 in 1946, was due to an increase in trade-union affiliations, the 73 affiliated unions accounting for 4,031,434 members. The nationalised industries were now an essential core of the great production impetus, but efficient public ownership by itself was not enough. Efficient private enterprise was equally essential.

In a communication issued last week by the General Council of the Trades Union Congress, it was stated that, according to the Ministry of Labour and National Service, there were at the end of 1946, 8,714,000 members of trade unions in industry. The total employment figure—which was 18,122,000—excluded men of 65 and over, women of 60 and over, and domestic servants, but included employers and self-employed.

Official figures relating to the coal-mining industry indicate that in the 14 weeks up to April 10, this year, the output of coal was 56,659,400 tons, compared with 52,596,100 tons in the corresponding period of 1947. Wage earners on the books of collieries in the week which ended on April 3—the latest date for which figures are available—numbered 723,200—a decrease of 600 compared with the previous week.

The Unemployment Fund had an income, in 1947, of 92,264,786*l*., which was 60,641,082*l*. more than its expenditure. The credit balance of the fund now stands at 491,742,385*l*. The agricultural account of the fund, which is published separately, received during the year 1,767,067*l*., which represented a surplus of 1,218,112*l*. over the expenditure. The credit balance in the agricultural account is now 12,889,028*l*..

Addressing a conference of the National Institute of Industrial Psychology at Buxton, Mr. Graham Satow, a director of training at Messrs. Stewarts and Lloyds, Limited, said that the foreman held a key position in a factory, but his status had been allowed to decline at a time when it was most needed to offset the general tendency to slacken effort. Foremen complained that a manager no longer relied on them as he used to do, that they had to ask his leave to do things which they formerly did on their own initiative, and that information about the firm's plans was often given first to shop stewards or joint production committees, so that they heard first of impending changes in their own department from the men working under them.

In Mr. Satow's opinion, the foreman's standing as part of the management must be emphasised. Foremen should be in the councils of the firm, information should go out through them, and their position should be marked by the small privileges which counted for a good deal on the factory floor.

The National Joint Industrial Council for the gas industry, agreed on Wednesday last week to grant the application of the employees side for increases of wages. Under the agreement—which is to have effect as from April 4—day men are to get an increase of 1½*d*. an hour, shift employees an increase of 4*s*. a shift, and piece workers a proportionate advance.

Representatives of the engineering trade unions belonging to the Confederation of Shipbuilding and Engineering Unions discussed with representatives of the Engineering and Allied Employers' National Federation on Wednesday last week the application of the unions for increases of wages. A national minimum and wage of 5*l*. 15*s*. a week is desired for skilled operatives, one of 5*l*. a week for unskilled employees. Mr. Tanner, the President of the Amalgamated Engineering Union, addressed the conference in support of the claims, and after some discussion, further consideration of the matter was deferred in order to enable the employers to consult their district associations.

The four unions which have women members employed in the engineering industry are seeking wage increases for them. They are asking for an advance of 14*s*. 6*d*. a week, which would raise the maximum time rate to 3*l*. 17*s*. a week. Women doing men's work at rates which have a fixed relationship with those of men doing the same job, are not included in this application.

"Admittedly," says the writer of the editorial notes in the April issue of the Amalgamated Engineering Union's *Journal*, "we must all face the facts of the present economic position, and while we cannot escape the obligations of our affiliation to the T.U.C. and decisions arrived at by such a conference as that recently held of trade-union executives, and while also we have a responsibility to tell the truth to our own members, we cannot admit that the economic position of the operative engineer is comparable to his value to the nation, or to the economic position of workers in a host of other industries where apprenticeships on low wage rates are not the practice, and where the worker is not called upon to spend a good proportion of his wages on the provision of tools and working clothing."

"In addition," he continues, "no other industry responds more to mechanical development with all the reduction in manufacturing costs that this automatically implies, and, although there may be individual firms that do not advance with the times, they cannot be permitted to determine the working conditions of the whole of the employees in the industry because of their lack of initiative."

"Let there be no misunderstanding of our position," he continues. "We say quite frankly: place the engineer on a status and under conditions not less favourable than those of his fellow-workers in other industries, and, as an industry, we will emulate, if not excel, the efforts of other trades. Already engineering leads the field in the export drive."

As these notes are being prepared, differences on the subjects of wages, prices and profits appear to be developing between the General Council of the Trades Union Congress and the Chancellor of the Exchequer. The rank and file of the trade-union movement do not, of course, disguise their dislike of the increases in the taxes on tobacco and beer. The General Council's position appears to be that not enough in the way of limiting prices and profits is being done to justify them in recommending the affiliated unions to adopt the White Paper's suggestion to refrain, for the time being, from pressing wage claims. Further conferences between the Crisis Committee and Ministers will, no doubt, take place. Whether they will lead to an improvement in this respect is not easy to say. The suggestion that what the Budget has failed to do, legislation might accomplish, would, however, if adopted, have inconvenient results for some unions—especially those which are ignoring the constitutional authority of the National Arbitration Tribunal.

LONGITUDINAL VIBRATION OF MARINE PROPELLER SHAFTING.*

By C. P. RIDBY, B.Sc., A.M.I.Mech.E.

(*Concluded from page* 383.)

DURING the first three trials, efforts were made to measure the forward movement of the main gearwheel relative to the gearcase, and to use the measured movement in conjunction with the calculable propeller thrust to determine the spring constant. The most serious difficulty lay in the fact that the gearwheel was vibrating with an amplitude of some ±0·010 in. at full power; and a further complication was introduced by the expansion of the shaft between the thrust collar and the forward end of the wheel during the appreciable time required for working up. Despite these difficulties, quite reasonable results were secured in the first ship. Results from later ships were not reasonable, and the method was therefore abandoned.

The second method of evaluation, also used in the first three ships, was the measurement of amplitude in the gland compartment by means of the vernier gauge. It was hoped that, from the relationship between gland compartment, thrust block and gearwheel amplitudes and the directly calculable spring constant of the shafting, it would be possible to solve for the unknown spring constant of the thrust block. This proved unsatisfactory because of the different character of the measuring instruments, the G.R. Vibration meter recording a mean value over some seconds while the vernier gauge gave the maximum peak values. Synchronisation of readings also offered difficulty, but probably this method could be made to work if sufficient attention were given to detail.

A third method, which the author has not tried, is the use of strain-gauges to measure the alternating compressive stress in the shaft close to the thrust block; such measurements, in conjunction with the vibration amplitude, would give the spring constant directly. The compressive stress in a shaft, however, is only about 1,500 lb. per square inch under full-power thrust and, by the time slip-ring difficulties are taken into account, the accuracy of measurement would probably be low. The method on which the present assumptions are based arises from the static deflection test, previously described. The considerable movement relative to each other of the forward and aft gland faces of the block under the static load has been used as a means of calculating the alternating load from vibration amplitudes recorded at the same two points during subsequent sea trials. The wing shafts of this ship are longer than the inner and so give a lower critical speed; and, if the same value of entrained water is allotted to each propeller, it is found that, to give the observed criticals, the wing thrust block must be stiffer than the inner. This is confirmed by the above calculation, which gives a flexibility, expressed as forward movement under full-power thrust, of 0·036 in. for the wing and 0·042 in. for the inner shaft. Using these figures, the weights of entrained water required to give the observed criticals agree within 2 per cent., and the mean value of 0·0481 ton per square foot of developed blade surface has been adopted as a standard.

It should be noted that, for a given first critical speed, the response of the system to other frequencies does not show any marked change if entrained water is increased and thrust-block flexibility reduced, or vice versa, until quite close to the second critical speed. The position of the latter is, however, controlled principally by the thrust-block flexibility and, when fitting a five-bladed propeller to a long shaft, it is important to know that it will be above full power. The most satisfactory method of sorting out the true values of entrained water and flexibility would be to take the system up to the second critical with a vibration generator. It is considered that the friction in the shaft bearings would be too great if this were attempted in dry dock, but consideration is being given to the possibility of attaching the vibration generator to the thrust block and carrying out the experiment while the ship is steaming at a moderate speed. In the meantime, trial results are worked up by using the above-mentioned standard allowance of entrained water and calculating the thrust-block flexibility from the observed critical speed. The resulting flexibilities vary in different ships from 0·036 in. to 0·057 in. forward deflection under full-power thrust. In estimating the critical speed for a new ship, with thrust block and seat of conventional proportions, a value of 0·045 in. deflection under full-power thrust should give results not far from the truth.

The value of thrust variation deduced from trial results is dependent on the amount of entrained water assumed, because that affects the calculation of thrust-block flexibility and hence the force required to vibrate the gearwheel with the observed amplitude. For this reason, the figures given below must not be divorced from their context: if, at any future date, the standard figure for entrained water is changed, the values of thrust variation must be re-calculated. If a reliable portion of the resonance curve is available outside the range 0·8 to 1·2 times the critical, the thrust variation may be calculated directly as the remainder in the tabulation method, for the observed gearwheel amplitude and frequency. Unfortunately, this is rarely possible, both because at the small amplitudes then obtaining other vibrations are liable to add appreciably to the amplitude, and because there is usually considerable scatter at the points. It has been usual, therefore, to find the dynamic magnifier at the propeller first and then to calculate thrust variation from the amplitude at the critical.

To find the dynamic magnifier at the propeller from trial results is a curve-fitting process. The ratio of propeller amplitude to gear amplitude is first calculated by the tabulation method for, say, 0·7, 1·0 and 1·3 times the critical speed, and a curve of this function is plotted. The propeller amplitude at the critical is found from the observed gear amplitude and the above ratio. Using this as the fixed point, a series of resonance curves for the propeller motion are calculated from the curves of Fig. 11, page 383, *ante*, using different values of the dynamic magnifier. Each is converted to gear amplitude and the best fitting is adopted. By definition, the thrust variation is the force which, if applied steadily, would move the propeller forward (by deflection of the thrust block and compression of the shaft) an amount equal to propeller amplitude at critical divided by the dynamic magnifier.

The results from the trials so far analysed show that the following figures may be taken as representative of the propeller-thrust variation with the ship on a straight course: three blades with "A" brackets, ±3 per cent. variation; three blades with bossings, ±4 per cent. variation; three blades, centre shaft, ±5 per cent. variation; four blades, three-quarters of above values, except for the centre shaft, where the variation would be greater than with three blades; and for five blades, three-fifths of three-blade values. It should be noted that H.M.S. Formidable, the basis of the figure for a centre shaft, has the structure sloped away below the shaft, so that her stern is midway between a bossing and a sternpost. It is probable, therefore, that a single-screw merchant ship would give a considerably higher thrust variation, especially with a four-bladed propeller. The figure of 3 per cent. for three blades and "A" brackets is close to the observed value of propeller torque variation under similar conditions.

It has been assumed throughout that all the damping present is at the propeller. This is certainly not quite true, but, so long as the shaft and gearwheel are supported on water and oil films in their bearings, the only other appreciable source of damping appears to lie in friction between the poorly lubricated teeth of the flexible couplings. This is an uncertain quantity, depending on the condition of the surfaces; the turbine rotors do not partake of the axial motion unless the coupling teeth have become very rough, when the balanced double-flow low-pressure rotor may do so. It does not appear, therefore, that the force is very great, and, when the thrust block is in the normal (forward) position, it is quite satisfactory to ignore this source of damping. When, however, the thrust block is 200 ft. from the gearwheel, it is just possible that the damping at the forward end might be sufficient to suppress the gear wheel motion and therefore to invalidate the conclusions drawn regarding very long shafts. The best way to find out would be to fit an extra thrust block well aft on such a line of shafting and to run trials with thrust pads fitted first in the aft block and then in the forward one.

Assuming that all the damping is at the propeller, the damping factor may be found from the propeller amplitude at critical speed, thrust variation, and frequency, using the relation between these factors previously quoted. Up to the present, the result has been expressed in terms of propeller developed surface, as for entrained water, and a representative figure is 0·00739 ton per inch per second per square foot of developed blade surface. The results of the trials with four-bladed and five-bladed propellers suggest, however, that the damping factor increases with the number of blades; and, if this is so, possibly it would be better expressed as 0·0177 ton per inch per second per foot of blade length. This point is under investigation.

The effect of turns has been studied under various conditions of speed and rudder angle on an inner shaft of a quadruple-screw ship and on the centre shaft of H.M.S. Illustrious, with the five-bladed propeller fitted. When a four-shaft ship turns to starboard with full rudder, the port inner shaft normally suffers a violent burst of vibration soon after the swing starts, becomes quiet while the ship is doing a steady circle, and then has another violent burst as she straightens up. The violent spells presumably occur when the slip stream of the wing propeller covers about half the disc of the inner, and the results from the quadruple-screw ship show that there is a rudder angle less than the maximum which will cause violent vibration to be maintained throughout a circle. This does not apply to the centre

Fig. 12.

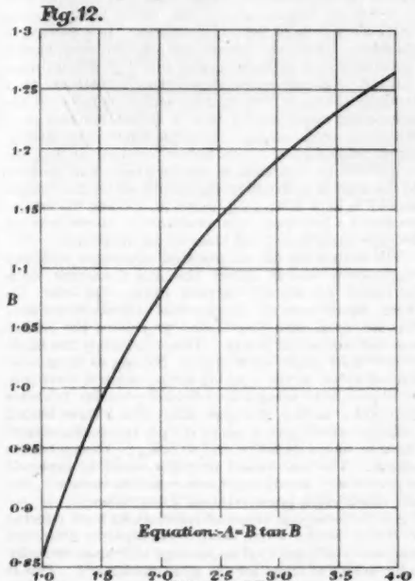


Fig. 13.

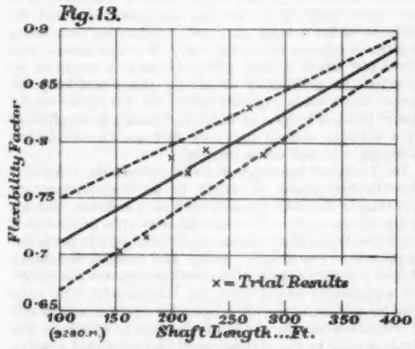


Fig. 14.

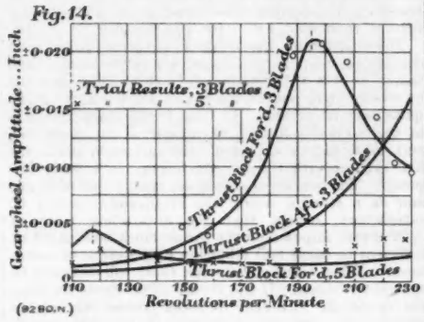
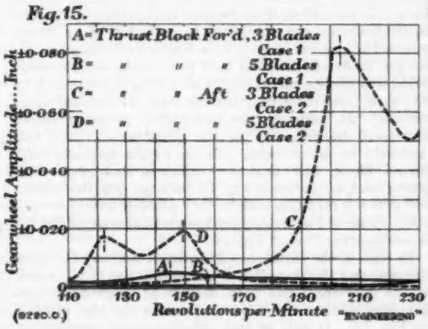


Fig. 15.



* Paper read at a meeting of the Institute of Marine Engineers, held in London on February 10, 1948. Abridged.

shaft of the triple-screw ship, because there the ship's structure prevents the slip stream from covering more than half the disc.

The results of the tests at different speeds show that, over the range from half to full revolutions, there is little change in the effect. The "turn factor"—the ratio of amplitude on turn to amplitude on straight course—has maximum values in the quadruple-screw ship of 4·96 at half speed and 5·4 at full speed; while, in the Illustrious, it is 4·1 at 102 r.p.m., 4·7 at 170, 3·7 at 210, and 3·2 at 220 r.p.m. These results are all for speeds where there is no reversal of thrust. In estimating amplitudes for new construction, a "turn factor" of 5 is used for quadruple screws in "A" brackets, and a factor of 4 for the centre shaft of a triple-screw ship. The latter figure does not mean that the triple suffers less on turns, but merely that it is worse on a straight course. The effect of turning is less in twin-screw ships, the turn factor amounting to about 2 and affecting principally the shaft on the inside of the turn.

Apart from the increase of vibration, another result of turning is important where fitting a five-bladed propeller may leave the second critical close above full power and where moving the thrust block aft may place the first critical in the same position. When a quadruple-screw ship turns to starboard and the slip stream of the port wing shaft covers the inner propeller, the latter is relieved of its thrust and speeds up rapidly. This increase of speed is liable to take it 10 per cent. above normal full-power revolutions and cannot be controlled when the tachometers fitted are of the integrating type. It is therefore necessary in the cases mentioned to consider revolutions up to 110 per cent. of the normal maximum.

When examining a proposed arrangement of shafting or drawing up a trial programme for a ship, it is desirable to have a short method of estimating the critical speed. Where the thrust block is in the conventional forward position, this is provided by treating the system as a weight (the propeller and entrained water) hanging on a heavy bar (the shaft between propeller and thrust collar). The flexibility of the thrust block is ignored initially and the method given by Timoshenko on page 209 of his book, *Vibration Problems in Engineering*, is used to determine the "rigid natural frequency." His equation can be reduced to: Frequency (vibrations per minute) $= 161{,}500 \times \frac{B}{L}$, where L = actual shaft length in feet, from propeller to thrust collar, and B is taken from Fig. 12, on page 405, which shows it plotted against a function "A." The value of "A" is simply: (weight of shaft) ÷ (weight of propeller + water); for this purpose, the weight of the shaft is taken as the actual length from thrust collar to propeller, multiplied by the weight per foot of the bare shaft. Couplings, gunmetal liners, etc., are ignored. The weight of entrained water used is 0·0481 ton per square foot of developed blade surface, as in the full method.

When the "rigid frequency" has been calculated, it must be multiplied by a "flexibility factor" to correct for the effect of thrust block flexibility. This has more influence on the natural frequency of a short shaft than on that of a long one, and Fig. 13, page 405, gives a plot of flexibility factor against shaft length based on trial results to date. If thrust blocks and their seats are made more rigid, this factor will increase towards unity.

The complete calculations for the natural frequency and amplitude of vibration of the centre shaft as fitted in H.M.SS. Formidable and Illustrious, with three-bladed and five-bladed propellers, give the calculated amplitudes on straight course reproduced in Fig. 14, page 405, in which it is seen that reasonable agreement with the trial results is secured. If Fig. 14 is compared with Fig. 5, page 382, *ante*, it will be seen that the calculated amplitudes with five blades fall considerably below the original estimate at the higher speeds. The reason for this is that the original estimate was made by calculating amplitudes and dynamic magnifiers at the first and second criticals and then filling in the space between by fairing together the appropriate single degree of freedom resonance curves, a procedure since found to be invalid for the flank of the second critical.

It will be noticed in Fig. 14 that the trial results for the five-bladed propeller fall below the calculated values at the left and above them at the right. The former discrepancy suggests that the five-bladed propeller has a higher damping factor than the three-bladed one, a point already discussed. The increased amplitude at higher powers is probably due to the centre shaft picking up from the hull the appreciable three-per-revolution vibration arising from the three-bladed wing propellers. This can be seen quite clearly on the Kelvin vibrograph record at 200 r.p.m., where, in spite of the five-bladed propeller, the centre shaft breaks into free vibration at 600 vibrations per minute, which is apparently the natural frequency in the Illustrious. From this and the position of the first critical, it is concluded that the Illustrious has a slightly stiffer thrust-block seat than the Formidable.

Regarding turns, the calculations show a heavy reversal at the critical speed with a three-bladed propeller, which is confirmed by hammering in the thrust block and rattling of the gears, and a slight reversal at the critical with a five-bladed propeller, which does not, in fact, occur. At the critical speed, on a straight course, the anticipated alternating force on the thrust-block seat is reduced from ±47 tons with three blades, to ±10 tons with five blades, and the trial results show an even greater reduction.

With the same line of shafting but with the thrust block moved to a new position about mid-way between gearwheel and propeller, and its stiffness has been increased from $2{\cdot}27 \times 10^3$ to $3{\cdot}25 \times 10^3$ tons per inch, the critical speed is raised with a three-bladed propeller from 195 r.p.m. to 250 r.p.m.; as can be seen in Fig. 14, this is a distinct improvement. The amplitude at full power, however, is still too great and if such an alteration were contemplated it would be necessary to increase the thrust-block stiffness still further, to at least $4{\cdot}0 \times 10^3$ tons per inch.

Three different thrust-block positions have been considered, and, in each case, the stiffness has been taken as $4{\cdot}0 \times 10^3$ tons per inch. This figure is unusually high, but, in the author's opinion, would be quite easy to achieve. In Case 1, the thrust block is in the normal position, 10 ft. aft of the gearwheel, and, as would be expected with so long a shaft, the first critical with three blades occurs at a fairly low power. The gearwheel amplitude is only ±0·0058 in., and on a straight course the arrangement would be satisfactory, except that the alternating force of ±22·9 tons imposed on the thrust-block seat might be sufficient to cause hull vibration in the event of resonance. When turning, however, there will certainly be a thrust reversal. If the thrust collar elects to jump the 0·050 in. clearance between ahead and astern pads and the pinions also shuttle, the resulting amplitude will be sufficient to damage the flexible couplings. Such jumping and shuttling is probably more likely where the critical occurs at a low speed, because the torque loads on coupling and gear teeth are reduced. With five blades, the first critical will be moved down to 88 r.p.m., and there may just be a thrust reversal when turning. If, however, the five-bladed propeller shows increased damping, as in the Illustrious, there will certainly be no reversal. Thanks to the specially stiff thrust block, the second critical is still above full power and, as shown in Fig. 15, on page 405, five blades will give a completely satisfactory performance throughout. It should be noted that the vertical scale of Fig. 15 is one quarter that of Fig. 14.

In Case 2, the thrust block is placed midway between the gear and the propeller. The amplitude of vibration at the gearwheel has been calculated, neglecting any damping at that end, and the results are also plotted on Fig. 15. It will be seen that even this position of the thrust block (which gives the maximum natural frequency) fails to move the first critical, with three blades, above full power, and that the gearwheel amplitude is very great, principally because it is now equal to that of the propeller. The results with five blades show considerably reduced but still excessive amplitudes, and illustrate the adverse effect of moving the thrust block on the second critical, which has been brought down quite near to the first.

The enormous amplitudes resulting when damping at the gearwheel end is neglected have an air of unreality and are evidently too great. For this reason, the force required to hold the gearwheel stationary has been calculated and it is found that, with three blades at 226 r.p.m. (the critical speed with the wheel held still), it would require a force of ± 10·1 tons on straight course. The low-pressure turbine is double-flow and, therefore, the only "anchor" available is the steam thrust of the high-pressure turbine, amounting to 4·46 tons at full power. Assuming a coefficient of friction of 0·1 for axial sliding in the flexible couplings, the force available to hold the gear is 2·6 tons, and it is evident that this will not be able to keep it stationary, even on a straight course. To calculate the actual gear amplitude under these conditions would be a trial and error process of assuming different amplitudes, until one was found at which the energy dissipated against viscous damping at the propeller and "dry friction" at the coupling equalled the energy put in by the thrust variation. A further complication would arise because the gear motion would not be truly harmonic. Even with the gear held still, the force on the thrust-block seat is ± 52·3 tons on a straight course at 226 r.p.m., and for this reason the arrangement, in any case, is not acceptable with three blades. If five blades must be used, there is no point in moving the thrust block at all.

In Case 3, the thrust block is placed only 80 ft. from the propeller, as far aft as possible, and the force required to hold the gear stationary is again calculated. It is found that, if the gear can be held, the first critical will lie above full power and that the force required to hold it with three blades at 230 r.p.m. is only ± 1·72 tons. It appears probable that, with this arrangement, the gear would actually stay still on a straight course but would move when turning. The force on the thrust-block seat on a straight course is only ± 11·5 tons with the gear stationary. It does seem possible that the arrangement of Case 3 might allow the use of three-bladed propellers with satisfactory results, but, before committing himself to such an arrangement, the author would wish to secure measured values of the coefficient of friction in flexible couplings and find a satisfactory method of predicting the resulting amplitudes.

The foregoing has given the data and methods for predicting the amplitude of vibration with normal shaft arrangements, but has not given any indication as to what is considered acceptable. From the machinery aspect, the principal criterion is excessive wear in the flexible couplings. Experience in naval vessels shows that an amplitude of ± 0·020 in. on a straight course is sufficient to cause rapid wear, and that ± 0·050 in. when turning can cause heavy scoring and even seizure of the tooth surfaces. It is concluded, therefore, that the amplitude should not exceed ± 0·010 in. on straight course and ± 0·025 in. when turning. In twin-screw ships, the ± 0·010 in. on a straight course is the limiting factor, subject to the overruling consideration that a thrust reversal must not occur when turning. In triple-screw or quadruple-screw ships with a "turn factor" of four or five, the amplitude on the turn is the criterion, and to keep to the limit of ± 0·025 in. the amplitude on the straight should be kept down to ± 0·005 in. When the critical occurs at a low speed, the avoidance of thrust reversal becomes more important than actual amplitude.

The author has had no practical experience with any single-screw vessels except the American-built ships converted to aircraft carriers during the war. In these, there was no longitudinal vibration problem because, even with four-bladed propellers, the critical was well above full power. This is probably the situation in most single-screw ships. So long as there is no critical speed in the running range, there is obviously no objection to using a four-bladed propeller behind a sternpost; in fact, it is quite likely that a three-bladed propeller would give a heavy six-per-revolution disturbance in such a situation and so bring in a second-order critical. The four-bladed propeller would be expected to give a very strong four-per-revolution variation, but not much eight-per-revolution disturbance.

All the foregoing data and calculations have referred to thrust blocks which have been separate from the gearcases and supported on seatings which are virtually independent of those for the main machinery. This is a very important point, because, if the thrust block is located in the gearcase—as, for instance, in the "locked train" design—the gearcase, turbines and condenser all become involved in the longitudinal vibration. It is also most difficult to provide adequate fore and aft stiffness under a large gearcase, because its own sump and the condenser are in the way. For this reason, it is advisable, where a high stiffness figure is required, to sacrifice the possibility of saving space and keep the thrust block on a separate seat. In all cases, a stiff thrust block is helpful in reducing vibration amplitudes on a straight course, but may increase the likelihood of thrust reversal when turning.

Dr. Forsyth* has suggested that, where the critical is close to full power, it would be an improvement to introduce a flexible element, such as a bellows, just aft of the thrust block. This would move the critical to a lower speed and also reduce the ratio of gear to propeller amplitude. The detailed design and possible flexibility of such a device require to be worked out and the resulting amplitudes could then be calculated. The only possible objection to this proposal is that the amplitude of vibration of the bulk of the shaft, which is the greatest mass in the system, would be increased relative to the propeller amplitude. The idea is under investigation and, until figures are available, no final conclusion can be reached as to its merits.

While the use of four or five blades instead of the standard naval figure of three is known to give entirely satisfactory results as regards vibration, there is a desire to explore other methods. The reason for this is that there is likely to be some loss of efficiency and increased risk of root cavitation when the number of blades is increased. The results so far do not make it possible to give any figures for efficiency, but tend to suggest a slight loss, and as neither the five-bladed nor the four-bladed propellers have yet been docked, it is not known whether there has been any cavitation erosion.

Once a ship is complete, it would be a major operation to move the thrust block and, for this reason, the only

* "Some Gear-Cutting Inaccuracies and their Effect on Gear Loads and Gear Noises," by Dr. S. F. Dorey and Dr. G. H. Forsyth. *Trans. N.E.C. Inst.*, vol. 63, page D 205 (1947).

ADHESION UNIT FOR MECHANICAL-HORSE TRACTORS.

practical alterations are to change the number of propeller blades or to increase the shaft flexibility. If the critical is near full power and the shaft is in "A" brackets, there is a free choice between four blades and five blades. Five blades will give the greater certainty of smooth running and the avoidance of thrust reversal on turns, but a four-bladed propeller is likely to be slightly more efficient and less prone to cavitation troubles. Where the critical is some way below full power with three blades, it is possible that the use of five will bring the second critical into the running range and it is wise to calculate the probable position of this. Where the propeller works behind a sternpost and the critical is within the running range, four blades should not be used. It may occasionally happen that the first critical is at, or just above, full power. In such a case, it is worth considering the possibility of fitting a new and stiffer thrust block in the original position and at the same time stiffening the seat. In many cases, it would be possible to fit a block with a base twice as long on the existing seat.

In new construction, shafts may be divided, having regard to their running speed, into four classes: short, medium, long and very long. With a short shaft, the first critical is above full power with three blades and no special precautions are required. Slightly longer shafts may be brought into this category by making a special effort to provide a stiff thrust block and seat. With a medium-length shaft, the first critical comes below full power with three blades when the thrust block is near the gearwheel end, but may be raised well above full power by placing the thrust block midway between gearwheel and propeller. In this case, the thrust block can be so located and a three-bladed propeller may then be retained. This arrangement requires either a self-contained, self-lubricating thrust block, or a separate lubricating-oil system, because the block is too far aft to allow oil to drain back to the engine room. Allowance must also be made at the gears for expansion of the shaft between thrust block and gearwheel. This will depend on the number of plummer blocks and bulkhead glands fitted; measurements taken in one ship show a movement relative to the hull of about $\frac{1}{16}$ in. per 100 ft.

A long shaft is defined as one in which the first critical cannot be moved above full power by moving the thrust block halfway to the propeller. In this case, it becomes necessary to change to four-bladed or five-bladed propellers, with the possible alternative of increasing the shaft flexibility. The thrust block should be kept in the forward position and made sufficiently stiff to ensure that the second critical is well above full power with the chosen number of blades. With a very long shaft, it appears possible, if the thrust block is placed as near as practicable to the propeller, for the friction in the flexible couplings to hold the gearwheel stationary under all conditions. If the truth of this conclusion can be established, and if the retention of three-bladed propellers is regarded as very important, this arrangement will warrant serious consideration.

PRICE OF GROUND SULPHUR.—The Board of Trade have issued the Ground Sulphur (Price) (Amendment) Order, whereby the maximum price of ground sulphur is increased by 12*s.* 6*d.* per ton.

ADHESION UNIT FOR MECHANICAL-HORSE TRACTORS.

AN interesting towing unit has been designed by the London Midland Region of British Railways, which enables tractors of the mechanical-horse type to be used for hauling four-wheeled trailers. Normally, these tractors can be used only for hauling semi-trailers fitted with two wheels at the rear, the front end of the trailers being supported by the rear of the tractor. The trailers are arranged so that they may be disconnected from the tractor with ease, thus making it possible for a single tractor to operate a shuttle service of trailers, the trailers being connected to the tractor automatically and a folding spring-operated leg supporting the front end of each trailer when not in use. Obviously, the adhesive weight for the driving wheels of the tractor is supplied by the laden trailer, so it is not possible to use the tractor for hauling four-wheeled trailers without providing weight fot adhesion in the form of a ballast box or by some other means. Any ballast box provided, however, must be simple to remove; furthermore, any brackets and fixings must not interfere with the functioning of the mechanism for connecting the two-wheeled trailers to the tractor

These difficulties have been overcome on those trailers operated by the London Midland Region by using ballast in the form of a concrete block fitted to a unit which takes the place of the forward attachment of the two-wheeled trailer, a tractor so fitted being illustrated above. This adhesion unit, as it may be termed, has three main parts, namely, a frame fitted with four small wheels, a towing member and the ballast weight referred to previously. The frame is fabricated from channel-section structural steel and has welded to it a mechanical-horse forecarriage rocking beam, the complete assembly forming a rigid structure which is located on the tractor chassis by the existing coupling gear. The front wheels of the adhesion unit are integral with the forecarriage rocking beam while the rear wheels are fitted to vertical support members bolted to the rear of the frame. The four wheels of the unit are located by the rails fitted to the tractor for the purpose of guiding the forecarriage of the semi-trailer to the correct position on the tractor. It will be appreciated, therefore, that if the towing unit is arranged at the same height as the forward end of a parked semi-trailer, the tractor can be backed beneath it and the unit locked to the tractor chassis by the existing mechanism, thus rendering the change-over exceptionally simple.

In addition to carrying the rear wheels of the adhesion unit, the vertical supports also serve to hold the rear of the unit to the tractor frame. This is accomplished by pins which pass through the vertical supports and under the rear of the tractor chassis; one of the pins and its attendant captive chain can be seen in the illustration immediately behind the near-side rear spring of the tractor The towing member consists of a laminated spring, to the centre of which is fitted a standard towing hook, the ends of the spring being located in slots formed in the upper ends of the vertical support members. The servo braking system of the tractor has been modified to operate the brakes of the four-wheeled trailers, the brake hose, together with the leads for the rear light, being relayed to the trailer from the rear of the adhesion unit.

CATALOGUES.

Flexible Bearings.—We have received from Messrs. Howard Clayton-Wright, Limited, Wellesbourne, Warwickshire, an illustrated brochure on their Harrisflex flexible-rubber bearings.

High-Voltage Alternators.—Messrs. C. A. Parsons and Company, Limited, Heaton Works, Newcastle-on-Tyne, 6, have recently published a pamphlet dealing with the high-voltage alternators which they construct.

Marine Oil Engines.—A booklet which illustrates the varied types of ships in which their marine-type Diesel engines have been fitted has been received from Messrs. Davey, Paxman and Company Limited, Colchester.

Single-Phase Current Rectifiers.—A pamphlet issued by Standard Telephones and Cables, Limited, Connaught House, Aldwych, London, W.C.2, gives technical details of the single-phase rectifier stacks manufactured by them.

Pneumatic Hammers.—The Hymatic Engineering Company, Limited, Redditch, Worcestershire, have issued a leaflet which describes their new light air-hammer. A range of tool kits available with the hammer enables it to be used for such jobs as the preparation of holes for Rawlplugs, stone dressing and sheet-metal cutting.

Mine Ventilation.—An informative catalogue has been received from Messrs. Davidson and Company, Limited, Belfast, Northern Ireland, on the subject of their Aeroto axial-flow fans for ventilating mines. The catalogue is divided into three sections, which deal with main ventilation, auxiliary ventilation, and performance estimation, respectively.

Cylindrical Grinder.—The principal data on the Newall "L.A." 10-in. cylindrical-grinding machine is given in a leaflet issued by the makers, the Newall Engineering Company, Limited, Peterborough. It is made in six sizes, of 24, 36, 48, 60, 72, and 84 in. between centres, and in all cases the maximum diameter of work that can be ground is 10 in.

Marine Transmissions.—Messrs. Modern Wheel Drive Limited, Chesham, Buckinghamshire, have issued a new pamphlet on their marine-type oil-operated reversing and reduction gearing. This latest pamphlet contains considerably more information than its predecessors and, with the aid of diagrams, explains clearly the principles of their SLM oil-operated clutch.

Fuel-Oil Burning Equipment.—An exceptionally attractive booklet has been received from Messrs. J. Samuel White and Company, Limited, Cowes, Isle of Wight, on the subject of their fuel-oil burning equipment. The booklet is well illustrated and describes in detail the various components of a typical fuel-oil burning unit. The equipment described is equally suitable for use with marine or industrial boilers.

Screwing Dies.—Messrs. W. H. A. Robertson and Company, Limited, Lynton Works, Bedford, have issued an illustrated booklet on the identification of screwing dies which they supply for dieheads, screwing machines, and handstocks. It is intended to assist those who have difficulty in obtaining dies of foreign or unknown origin. The booklet contains references to 90 British, American and Continental makes.

Diesel Engines.—Messrs. Associated British Oil Engines Limited, 32, Duke-street, London, S.W.1, have issued a booklet which describes in detail the range of land and marine-type Diesel engines manufactured by Messrs. Mirrlees, Bickerton and Day, Limited, Stockport, Cheshire. An abridged specification, together with power and fuel-consumption curves, is given for each type of engine, while the overall dimensions are shown on simplified line diagrams.

Universal Tool Head.—A milling machine, jig borer, or drill press may be used for boring, counterboring, facing, undercutting, turning, trepanning, recessing and back facing, by using a universal tool head manufactured by Messrs. Optical Measuring Tools, Limited, 414, Montrose-avenue, Trading Estate, Slough, Bucks. Two models, Nos. 0 and 1, are described in a leaflet issued by the firm. The No. 0 head will bore holes from $\frac{1}{16}$ in. to $1\frac{1}{4}$ in. in diameter, and the No. 1 head holes from $\frac{1}{4}$ in. to 12 in. in diameter. The radial position of the tool can be adjusted to within 0·0005 in., while the machine spindle is running.

Ships' Soot Collectors.—Two systems for removing dust and soot from the funnel gases of ships are described in a booklet issued by Messrs. James Howden and Company, Limited, 195, Scotland-street, Glasgow, C.5. Both employ one or more cylindrical chambers containing a series of fixed vanes, which impart a whirling motion to the gases and cause the heavier particles to be thrown out. In the Howden vortex dry-type collector, the particles are transferred to another chamber, whence they fall to a flushing hopper; and in the wet-type collector the particles are carried away by a descending film of water on the inside of the chamber. The extraction efficiencies are stated to be 84 per cent. and 97 per cent., respectively.

NOTES ON NEW BOOKS.

Production Engineering Jig and Tool Design. By E. J. H. JONES, M.B.E., M.I.P.E. Fifth edition. George Newnes, Limited, Tower House, Southampton-street, Strand, London, W.C.2. [Price 17*s.* 6*d.* net.]

SOME books on production problems have appeared recently in which an abundance of catalogue-type illustrations has to compensate for paucity of description, and absence of real explanation. It is satisfactory to find, however, that engineers are quick to appreciate a really conscientious work. Mr. E. J. H. Jones's book is, indeed, a first-class treatise, and the fact that a fifth edition has been found necessary since it was first published in 1940 shows how widely it has been welcomed. The publication of text-books is seriously limited at present in this country, but works of this calibre demonstrate how much more valuable is quality than quantity. No material alteration has been found necessary since the fourth edition appeared; but the opportunity might have been taken to correct the ascription of the foreword, as Sir George Bailey's presidency of the Institution of Production Engineers was contemporaneous with the first edition, of eight years ago.

Automobile and Aircraft Engines. Volume I. *The Mechanics of Petrol and Diesel Engines.* Fourth edition. By ARTHUR W. JUDGE. Sir Isaac Pitman and Sons, Limited, Parker-street, Kingsway, London, W.C.2. [Price 25*s.* net.]

THIS book requires no introduction, having been published first over thirty years ago. Subsequent editions, however, were revised and enlarged, so that it became unwieldy. The decision was made, therefore, to issue it in two volumes and the present book is based on that section of the original work entitled "Mechanics of the High-Speed Internal-Combustion Engine." In this latest edition, the original matter has been revised considerably, much of it having been deleted or rewritten; in addition, new chapters have been included which relate to the study of engine vibrations, engine mountings, torsional vibrations, the balancing of rotating parts, balancing machines, and valve cams and followers. The remaining chapters deal, in turn, with piston velocity and acceleration, engine torque and torque diagrams, flywheels and the effects of inertia forces. All the subjects have been presented in a practical manner, and a liberal use of diagrams has been made. The author has not assumed that the reader is well versed in higher mathematics and no practical engineer should experience difficulty in understanding the subject matter. Some of the diagrams, however, are somewhat small, a condition imposed, no doubt, by present restrictions.

Steel Files: Their Manufacture and Application. By ERIC N. SIMONS. Sir Isaac Pitman and Sons, Limited, Parker-street, Kingsway, London, W.C.2. [Price 15*s.* net.]

WHILE books on machine tools and their use are fairly numerous, there is a notable scarcity of manuals on hand tools; it may almost be said that, the more common the tool, the more scanty is its literature. This generalisation certainly applies to the file, and Mr. Simons has done well to follow his handbook on *Saws and Sawing Machinery*, which we reviewed on page 44 of our previous volume, with this excellent compendium on files, into which he has compressed a remarkable amount of information on their history and development, manufacture, characteristics, and use. In an appendix he gives the simplified war-time list of files, with their prices; and another appendix contains tables of the weights of precision and needle files, in English and metric values. Not the least illuminating of the features of the book, to the engineer who is accustomed to only a dozen or so of types and cuts, is the insight that it provides into the wide variety of special files produced for particular industries; numerous as the examples are, the author points out that they are no more than representative of a much more extensive catalogue. The concluding chapter, on "The Future of the File Industry," may be commended to students of other handicrafts for its common-sense approach to the question of rationalisation of production as an essential condition of prosperity, and even survival.

STEEL AND IRON PRODUCTION IN THE UNITED KINGDOM.—Steel production in March was at the annual rate of 15,117,000 tons, which constitute a new record in spite of the Easter holidays. This figure compares with a rate of 15,049,000 tons in February, the previous record, and with only 10,190,000 tons in March, 1947, which total was affected by the fuel crisis. Pig iron showed a further improvement, reaching an annual rate of 9,303,000 tons in March last, compared with 9,169,000 tons in February and only 6,400,000 tons in March, 1947.

"ENGINEERING" ILLUSTRATED PATENT RECORD.

ABSTRACTS OF SPECIFICATIONS RECENTLY PUBLISHED UNDER THE ACTS OF 1907 TO 1939.

The number of views given in the Specification Drawings is stated in each case; where none is mentioned, the Specification is not illustrated.

Where inventions are communicated from abroad, the Names, etc., of the Communicators are given in italics.

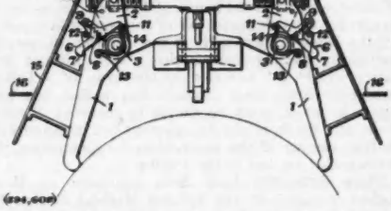
Copies of Specifications may be obtained at the Patent Office Sales Branch, 25, Southampton Buildings, Chancery-lane, London, W.C.2, price 1s. each.

The date of the advertisement of the acceptance of a Complete Specification is given after the abstract in each case, unless the Patent has been sealed, when the word "Sealed" is appended.

Any person may, at any time within two months from the date of the advertisement of the acceptance of a Complete Specification, give notice at the Patent Office of opposition to the grant of a Patent on any of the grounds mentioned in the Acts.

AERONAUTICS.

594,606. Temporarily Attaching Articles to Aircraft. Blackburn Aircraft, Limited, of Brough, East Yorkshire, and A. Tharratt, of Hessle, East Yorkshire. (3 *Figs.*) May 30, 1945.—This invention is a device for securely attaching to aircraft articles which are temporarily carried externally, such as bombs, jettisonable tanks, etc., and for releasing them at will while in flight. The articles are held by one or more pairs of crutch arms. Each crutch arm of a pair comprises two limbs 1, 2, both of which pivot on fixed shafts 3. The free end of the limb 2 is pivoted to an adjusting mechanism in the form of a slide 4, displaceable along a rotatable threaded rod 5, and this limb also carries a latching member or three-arm lever 6, which has a latching nose 7 at one end of one of its arms. The latch 6 pivots at the junction of its arms at 8, and a tension spring 9 extends between the extremity of one arm and the shaft 3 to have an over-centre action serving to urge the latch 6 into its alternative limit positions in which it is retained by another of its arms engaging a stop pin 10 on its carrying limb 2 in the one direction, and by engaging a pin 11 also provided on this limb in the



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other direction. The limb 1 of the crutch arm at its free end engages the carried part, and near its pivot end has a projecting portion carrying a pin 12 which moves into engagement with one arm of the latch 6 to rock it. On the same side of the limb is a pin 13 with which the nose 7 of the latch 6 engages and a torsion spring 14 extends from the pin 11 around the shaft 3 to the pin 13 to tend to urge the limb 1 into the retracted position, i.e., in counter-clockwise direction in the case of the left-hand crutch arm and in clockwise direction in the case of the right-hand crutch arm. The limb 1 carries a part 15, which, when the limb is retracted, closes the gap in the surface 16 of the aircraft wing or fuselage through which the limb projects in its extended position. When the spring-loaded limb 1 is rocked out of the retracted position against the action of its spring 14 until the pin 13 is engaged by the nose 7 of the latch 6, it is capable of still further movement before abutting on to the other limb 2. On giving further movement to the spring-loaded limb 1 the pin 12 thereon becomes effective on the one arm of the latch 6 and rocks the same over-centre to render the latch ineffective. At this time, the spring-loaded limb is free to retract and is only prevented from retracting by engaging the article carried. (*Sealed.*)

MOTOR VEHICLES.

593,814. Springing of Vehicles. The Austin Motor Company, Limited, of Birmingham, and J. C. Haefeli, of Birmingham. (4 *Figs.*) April 14, 1945.—The invention relates to independent spring suspension from the steering wheels of road vehicles. Its object is to eliminate "shimmying" or "wobble" and maintain the castor angle constant as the stub axle rises and falls in relation to the chassis frame or vehicle body. In the drawings, A indicates one of the side-frame members of a motor-vehicle chassis, B a carrier, to which is connected a stub axle C through the usual steering axis. The wheel C^1 (not shown in elevation) is mounted on the stub axle C in the usual manner. The carrier B has a lug *b* extending upwards and a lug b^1 extending downwards. To the lug *b* is pivoted the rear end of a forwardly extending link D, which, at its forward end, is splined to a torsion bar E. This latter passes inwards through a tube F, to the interior of which it is splined at the middle point. The tube F is rigidly carried at its ends in brackets one of which is shown at *f*. Each of these brackets is secured to the respective frame member A. Similarly, the lug b^1 is pivoted to the forward end of a rearwardly extending link D^1, which, at its rear end, is splined to another torsion bar E^1 housed in, and splined to, another fixed tube F^1 carried in brackets, one of which is shown at f^1.

Fig.1.

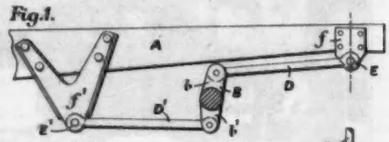
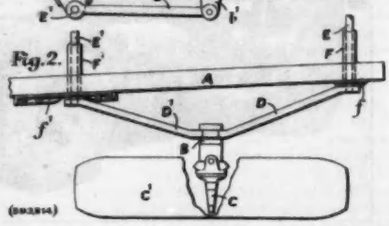


Fig.2.



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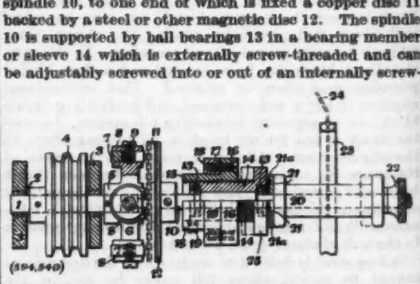
When passing over an irregularity of the road the wheel moves up in relation to the chassis frame and the carrier B goes up with it, but the carrier, as seen in side elevation, is maintained, to a close approximation, in the same angular relation to the chassis frame by the links which rock about the axes of their respective torsion bars and obtain spring support therefrom. Alternatively, they can be simply pivoted to the brackets, the carrier B being then supported by coiled or other springs placed between it and abutments of the chassis frame. If desired, the swivel axle pin may itself form the carrier, in which case the two links would be connected to its two ends by suitable universal joints. (*Sealed.*)

MISCELLANEOUS.

594,540. Apparatus for Winding Threads, Wire or Ribbon. The United Wire Works Limited, of Granton, Edinburgh, and W. D. T. Green, of Edinburgh. (2 *Figs.*) September 29, 1944.—The invention is a device for winding threads, wire, ribbon strips or other sheet material on to bobbins or reels at a constant linear speed. A shaft 1 is mounted in bushes 2 in bearing brackets 3 forming part of the winding-machine frame. The shaft carries a double-grooved belt pulley 4 driven from any suitable prime mover. Also fixed upon the shaft 1 is a magnet carrier 5 having radial arms 6, the outer ends of which support horseshoe magnets 7 held in position by washers 8 and screws 9. The magnets can be adjusted so that all their pole faces are in a plane normal to the axis of the shaft 1. Coaxial with the shaft 1 is a winding spindle 10, to one end of which is fixed a copper disc 11 backed by a steel or other magnetic disc 12. The spindle 10 is supported by ball bearings 13 in a bearing member or sleeve 14 which is externally screw-threaded and can be adjustably screwed into or out of an internally screw-



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threaded collar 15 having a flange 16 secured by screws 17 to a bearing bracket 18 forming part of the winding-machine frame. A locking screw 19 enables the bearing sleeve 14 to be secured in adjusted position within the collar 15. The winding bobbin 20 is fixed on the spindle 10 between a washer 21 and a securing nut 22 which is screwed upon a threaded end portion of the spindle 10. The washer 21 has a boss or sleeve extension 21*a* which bears against the inner race of the adjacent ball bearing 13, so that the washer 21 rotates with the spindle 10 clear of the flange 25 of the sleeve 14. A traversing guide, indicated diagrammatically at 23, lays the wire 24 on the bobbin in known manner, the wire being fed thereto from a feed wheel which is driven at a constant speed by a belt from the pulley 4. The driving torque on the winding spindle can be readily adjusted to suit requirements by increasing or decreasing the air-gap between the disc 11, 12 and the magnets 7. This can be done by releasing the locking screw 19 and rotating the bearing sleeve 14 in the collar 15. (*Sealed.*)